ENGINEERING 28-6-57

ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 183 No. 4764 *LONDON, FRIDAY, JUNE* 28, 1957 PRICE 2s.

STRAIGHTENING SEAMLESS TUBE

Nurnberg photograph for ENGINEERING

JUNE 28, 1957 VOL. 183 PAGES 801–832

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Published every Friday by Engineering Limited, 35 & 36 *Bedford Street, Strand, London, W.C.*2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663.

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s*., *Canada* £5 5*s*. *Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s*. 3*d*.)

TOO OLD AT WHAT?

BRITAIN is in the throes of adjusting herself to the consequences of having an ageing population. The subject is full of prejudice, contradictions and a whole mass of subjective valuations. It is a topic on which people as a whole can hardly be expected to be objective. In the end it is a problem which comes to us all.

It would be wrong, however, to imagine that all the contradiction and prejudice come from those who are now or who soon will be old-age pensioners. There is conflict enough among those whose job it is to be objective. On the one hand evidence is produced to show that older people should be able to work to a greater age than hitherto. Medical science gives us all a greater expectation of life at birth than in grandfather's time, though it has to be conceded that the figures offer us very little greater expectation of longevity as we approach conventional retirement age. The burden of the figures is rather that we are less likely to die young than that we are going to live to a ripe old age. The other school of thought points to the greater physical and mental strain of modern life. It says that there is a premium on speed, quick-wittedness and endurance and these are not qualities which the average person preserves into old age. This line of thought thus leads to the conclusion that people should work less hard and under less strain in later years.

A third and powerful influence is also at work. In this age of inflation most people have to work as long as they can. We all face the prospect in old age of living off a comparatively stable money income while the cost of living rises. The pressure of insurance salesmanship and Government policy has been to encourage growing dependence on fixed incomes in later life. The growth of with-profits policies and the increasing interest of the insurance companies in equity investments is some sop to the old-age pensioner living off a fixed income but it is a small one. Government policy is aimed, irrespective of party, at penalising the independent man who may wish to make his own provision for old age. Legislation on a national pension scheme may at one blow make us all State pensioners with our incomes related to a sliding scale, but this will only mortgage the future as far as the economy as a whole is concerned. Until such legislation arrives, the urge to work as long as possible in order to defend one's standard of living is a powerful motive force, especially among the better paid of the working population.

In this mass of contradiction there is a good deal of data still lacking. We still know remarkably little about the efficiency of older people, either in the jobs which they have done all their lives or in some kind of light work which they may take on in later years. A certain amount of objective work has been done to show on the one hand that men and women can work remuneratively (to all concerned) when they are older at special, light and unhurried work. A good deal of medical evidence, supported by sociological investigations, has gone to show that the average person is slower on the job as he gets older. Employers get the reputation, not always deserved, of being in favour of early retirement because men are less efficient in later life. The unions get the reputation, sometimes equally unearned, of being favourably disposed to the older worker. American experience has shown that the unions have been able to negotiate special conditions for older workers in jobs without much difficulty but they have rarely had a policy of doing anything for the older man who wants a job. No data on the subject have been analysed in this country.

There are certain conventional attitudes. Judges, professors and clergymen are thought to be able to carry on late in life since cumulative wisdom and experience is at a premium for them rather than original creative work. Senior company officials, at least at board level, benefit from the same impression and so do many professional men. In popular thinking, it is the nearer a man gets to physical, rapid repetitive work that the problem becomes most acute. There is great need for scientific research on the productivity of older workers. We want to know if their decline in productivity is measurable and if so what the figures look like. We want to know what kinds of work are measurable especially on the shop floor on comparative kinds of work. It is more than likely that data can be compiled to relate efficiency and age for bus drivers or operatives tending mass-production machines.

The purpose of such evidence, where it could be found, would be to find out how far older people can be gainfully employed or whether it would be better for the community to pension them off completely, thereby releasing resources for the younger to use more productively. In other words it is not a mere question of trying to prove that older workers can make a contribution to the national income by continuing in work but to show that this contribution would not be bigger if the resources that are available were used by younger age groups. Where judgment and experience are required it is possible to say fairly quickly no doubt that the older man justifies his position. With physical exertion the answer is less apparent.

From the human point of view, there is

much to be said for letting older people continue in work as a means of self-expression. Not all of us want to be put out to grass. There is probably some social justification, in consequence, for keeping retirement ages higher than they would otherwise be on economic grounds on work involving physical exertion. If this is so it should be clearly admitted. If we want people to stay in jobs above a certain age and we are not prepared to take the trouble to prove we are right economically, then we must accept the fact that it is part of the burden on the community of an ageing population. There are those who may say that as a population gets older everyone can be expected to work longer, but such a conclusion is based on a counting of heads. There is a point, wherever it may be, where instead of counting heads it is necessary to start adding up what the heads—and the bodies—can do.

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Plain Words

For some, leaving college is like going to prison. After three, perhaps four, years of liberal freedom, all garlanded with sweetness and light, the graduate must gather his personality together and ram it into a routine for which he has been ill prepared. Listening to quartets in the small hours, bright gossip over a leisurely mid-morning coffee, rowing once a day, breakfast at Grantchester after dancing all night, perhaps a few well-chosen lectures, and then, suddenly, a harsh new world of nine-till-five reality, with at best a game of football on Saturday afternoons. If the graduate has the misfortune to be an engineer beginning an apprenticeship, he may even find that he is expected to clock on—at 7.30, when most undergraduates are still in bed. Education is supposed to be a preparation for life—sometimes a life, unfortunately, that few of us can lead.

To carp at the bounty of a liberal education is to appear ungrateful, but its place in life to-day is clearly due for re-examination. Currently, the two most publicised educational requirements are for more and better engineers, and for a broader and more liberalised engineering education. Can the two be reconciled? Is a compromise possible? Attention has been drawn to the success of Russian polytechnics, but where a few lectures on Marxism are the only rival claims to a student's interest, his discipline is unlikely to be undermined. And whereas in Cambridge "*das Betreten's* not *verboten*," in Kiev it is probably compulsory. There, the step from college to industry may be an easy one.

At least one company in Britain have recognised the traumatic adjustment the graduate is required to make, and thoughtfully included in their apprenticeship brochure inviting references to the full civic life, complete with Halle orchestra and an attractive countryside, available to their employees. But for the others, nostalgic contact with the sparkling intellectual life of college can only be kept up through the *New Statesman and Nation* or the " posh [Sunday] papers."

Recently the *Sunday Times* published pictures of young men and women who were in residence at Oxford some ten years ago and have since become successful. Not one was a technologist. Most were engaged in the tertiary activity of entertaining us. Entertainment does, in fact, seem the sole livelihood able to satisfy the delicate appetites created by high-class British education; the only satisfactory alternative is to become a piping goatherd on some sunny Aegean island. It is really not surprising that so many of our talented young men say in effect: " T'hell with engineering, I'm going to be a poet."

RADIATION FOR INDUSTRIAL PROCESSING

Using Radioactive Fission Products on a Large Scale

By R. Roberts, M.SC., PH.D.*

Four products are obtained from a nuclear pile; heat, subsequently converted into electricity, plutonium, which will be used as a fuel for newer types of reactors, depleted uranium, that is uranium in which part of the uranium 235 has undergone fission, and last of all the fission products. These are simply the fragments formed from the uranium nucleus after it has undergone fission, and they are highly radioactive chemical elements with atomic weights ranging between 72 and 162. Very large quantities of radioactivity are available from these fission products. In generating 6,000 MW of electricity each year, 10 tons of uranium 235 must undergo fission and, at the same time, 3·5 tons of fission products will be obtained. The weight of fission products is therefore not very large, but the radioactivity associated with them is enormous. It can be shown that by 1965, when Britain plans to have an installed capacity of 6,000 MW from nuclear sources, the radioactivity produced each year will be equivalent to a steady source of 3 thousand million curies (the curie is a unit which measures the amount of a radioactive substance, and is that quantity of radioactive material which emits $3{\cdot}7 \times 10^{10}$ particles or rays each second. It is, in fact, equivalent to the radioactivity associated with one gram of radium.) It is worth noting that the entire pre-war supply of radioactivity was of the order of a few hundred curies. With only this small quantity available, it was quite out of the question to contemplate the use of radioactivity for industrial processing. Now, from the atomic power programme, we shall have many hundreds of millions of curies of radioactivity, and it becomes possible for the first time to contemplate the use of this radioactive material for large-scale processing.

Fuel Rods as Radiation Sources

In nuclear power technology there are two points at which the radioactivity associated with the fission products might be conveniently used. The fission products are, of course, first formed within the uranium fuel elements, and therefore these fuel rods on withdrawal from the pile are intensely radioactive. The radioactivity from most of the fission products dies away quite rapidly and it is, therefore, always common practice to store the fuel elements under water for some time before processing, thereby decreasing the amount of radioactivity which must be handled in the separation plants. These fuel rods represent an extremely radioactive source, which can be used both for laboratory experiment and also for industrial processing. From a comparatively small number of fuel rods very large radioactive sources can be built up and can be used for irradiating materials carried on a conveyor belt as indicated in Fig. 1. For some years now a large source has been in operation at the Materials Testing Reactor in the United States, and at Harwell it is hoped within the next few months to have a source of average energy of three million curies, made up of fuel rods from the new reactors DIDO and PLUTO.

Separated Isotopes as Sources

After the initial storage period the rods are sent to a separation plant for the recovery of the plutonium and uranium. From these plants an effluent containing the highly radioactive fission products is obtained. This effluent cannot be placed in the sea and must therefore be stored for many years. Lengthy storage is necessary because the two longest lived radioisotopes present in the fission products are strontium^{90} and caesium^{137}, which decay so slowly that they have only lost half of their radioactivity in 25 years and 30 years respectively. All the other fission products which are formed in any appreciable quantity lose most of their radioactivity within three years. It is, therefore, immediately obvious that, if the strontium and caesium are separated from the fission products, the residue obtained from this process would be relatively innocuous and could after storage for a period of ten years or so be thrown away into the sea. The separation of caesium and strontium into compact sources would therefore materially ease the effluent problem. The amounts of caesium and strontium radioactivity which will be obtained are quite large, approximately 30 million curies of each isotope. This quantity is quite sufficient to sustain large scale processes. The two isotopes, caesium^{137} and strontium^{90}, are essentially complementary to each other. Strontium^{90} emits beta particles and can therefore be used in cases where only a limited penetration is required, or, alternatively, where surface effects are desired. Caesium^{137} emits penetrating gamma radiation and requires much more shielding. On the other hand, its ease of penetration makes the irradiation of thick samples comparatively simple.

* Isotope Division, Atomic Energy Research Establishment, Harwell.

Potential Uses

The many industrial uses which have been suggested for radiation range over a wide field of physics, chemistry and biology. The earliest work on the large-scale use of radiation was carried out by radio-therapists, who for many years have used large sources in the treatment of malignant diseases. These early workers were responsible for many of the ideas which have now been put forward for the large-scale use of radiation in biology. For many years now it has been known that living organisms could be killed by radiation. Bacteria, for example, are killed by a dose of 3×10^6 roentgens. This method of sterilisation by radiation differs from the conventional method in that the material being irradiated is not heated.

Sterilising Food

Radiation can therefore be used for the sterilisation of any substance which is adversely affected by heat, for example, fresh food might be sterilised without cooking. Such a process would be of considerable military advantage, since it would render refrigeration largely unnecessary. The importance which is attached to this problem in the United States can be gauged from the fact that the current American budget in the field of radiation sterilisation is of the order of 10,000,000 dollars each year. In spite of the employment of a very large research effort, the problem of food sterilisation by radiation has not been completely solved. Although food of all sorts can be completely sterilised by doses of the order of 3×10^6 roentgens, undesirable odours and flavours are produced. A partial solution to the problem has been achieved by low-temperature irradiation, but the complete solution still eludes scientists. It should be emphasised that the amount of chemical change which has taken place in the food is very small, but nevertheless the organs of taste and smell are so sensitive that they can detect the small amount of chemical change giving rise to these off odours and flavours.

Although the problem of the complete sterilisation of food is complicated by the odour and the flavour changes, some progress has been made in the partial sterilisation of food by

radiation. In this case a much smaller radiation dose is given so that odour and flavour changes are not appreciable. The bacteria are not, of course, completely eliminated and the food will eventually go bad, but because of the reduced number of bacteria, food treated in this way will last much longer than the untreated variety. For example, irradiated minced beef will keep for fifteen days instead of three.

Drugs and Tissues

The problem of odour and flavour changes is not important when the sterilisation of such materials as drugs is considered. Many drugs, such as the antibiotics, cannot be sterilised by conventional processes using steam, since they are decomposed by heat. It has, however, been shown that these materials can be completely sterilised by radiation doses of 3×10^6 roentgens. No change in the potency of the drug takes place and the only physical effect observed is a slight change in colour. At the moment these drugs which are sensitive to heat are not sterilised. They are prepared and packaged under sterile conditions and the manufacturer uses extensive sampling procedures in order to ensure that the drugs are not contaminated. The cost of these procedures is high, and even when they are carried out there is no absolute guarantee that the packaged material is sterile. Radiation, on the other hand, offers the pharmaceutical manufacturer the same degree of complete sterility of these sensitive products as heat sterilisation offers in the case of materials which are thermally resistant. The sterilisation of a large number of other medical and surgical products has been reported, for example catgut and hypodermic syringes.

A new development in this field has been the sterilisation of living tissues. In the United States it has been discovered that arteries can be removed from cadavers, sterilised by radiation and kept for many months until they are required for transplanting. Similar work has been carried out on the sterilisation of bones used for grafting. So far, over two hundred people in the United States have received successful bone grafts using radiation sterilised material. Already in the United States one pharmaceutical company is marketing an eye ointment which has been sterilised by radiation. Many other applications are reaching the stage of commercial exploitation. The sterilisation of pharmaceutical products will undoubtedly lead the way, but it is felt in many quarters that the outstanding problems in the sterilisation of food may be satisfactorily overcome within the next two or three years.

Pests and Insects

A considerable amount of work has been carried out in the control of insects using radiation techniques. One of the most interesting discoveries in the field of insect control has recently been made by the United States Bureau of Health. Radiation has been used in the complete elimination of the screw-worm fly from the island of Curacao. This fly, which is a serious pest of South America, mates only once. Scientists from the United States Bureau of Health were, therefore, interested in investigating what would happen if a natural population of screw-worm flies were mixed with a large number of insects which had been sterilised by radiation. It had been previously shown that a comparatively small dose of radiation given to the pupae of this insect would lead to the development of adults which could lay only sterile eggs. It was found that on mixing a natural population with one which had been radiation sterilised the reproduction rate of the mixed population decreased rapidly, roughly in the proportion of the sterilised to normal insects. It was then realised that if sufficient pupae could be sterilised, reared to adult insects and then mixed with the natural population, the reproduction rate would be very much decreased and eventually the population would fall below the level where natural reproduction would be able to maintain it, and the insect would therefore die out. A large-scale trial was therefore carried out on the island of Curacao. The island was first sprayed with insecticide to reduce the natural population as much as possible. Large numbers of sterile flies were then liberated, the quantity being of the order of millions each day. After some weeks the egg masses laid by the flies were investigated and it was found that these were completely sterile. After a few months the screw-worm fly had completely disappeared and to date has not reappeared. There are two advantages of this method as a means of insect control; firstly, the population can be entirely wiped out. The use of chemical insecticide becomes progressively more costly as the number of survivors decreases, since the quantity of insecticide which has to be laid down to kill off the last survivors would be enormous. On the other hand, the sterile fly acts as a winged insecticide and actively seeks out the natural population, hence ensuring that the very last survivors are eliminated. In contrast to the use of insecticide the method is at its most efficient when the population is at its lowest, since the number of sterile flies which must be bred is much reduced. The second advantage is, of course, that the method is highly specific, killing off only one insect.

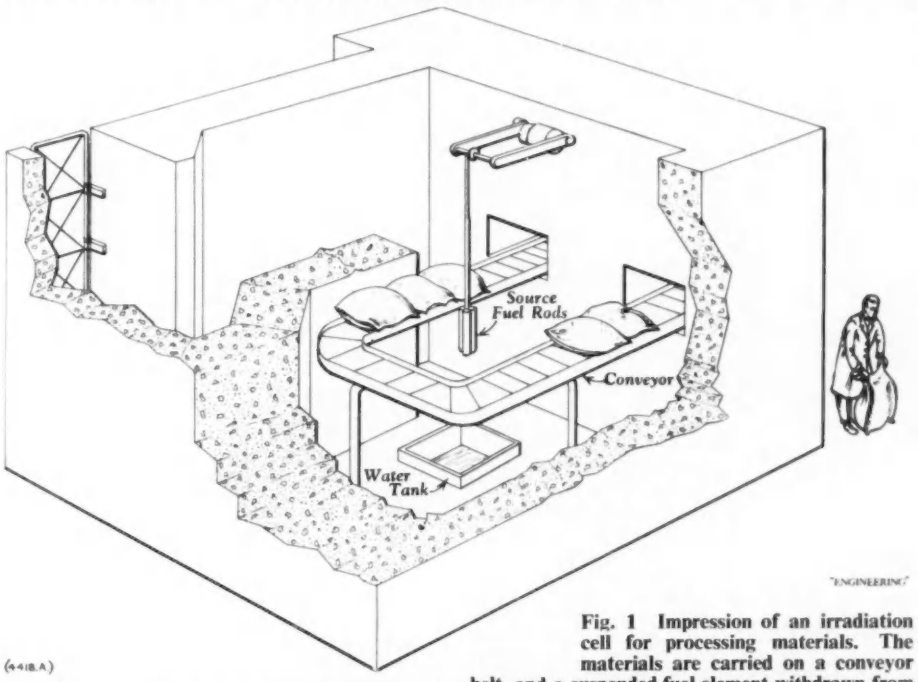

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Fig. 1 Impression of an irradiation cell for processing materials. The materials are carried on a conveyor belt, and a suspended fuel element withdrawn from a nuclear reactor serves as the radiation source.

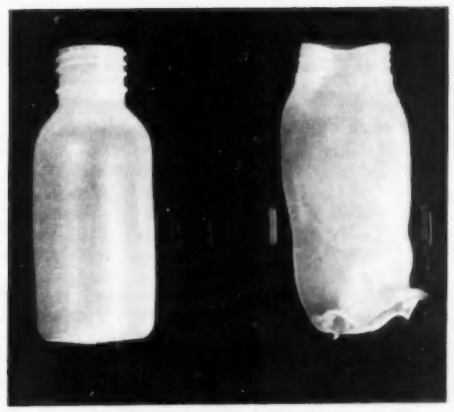

Fig. 2 The physical properties of materials may be modified by irradiation. Both the Polythene bottles illustrated have been heated for similar periods at 120 deg. C. The one on the left has been irradiated with a dose of approximately 5×10^7 roentgens, whereas the unirradiated control specimen on the right has clearly melted.

Processing Materials

Radiation effects in physics and chemistry can be broadly divided into two main types, those in which radiation is used for the complete synthesis of a given material and others in which the radiation is used to alter the physical properties of an already manufactured substance. The use of radiation in physico-chemical processes is largely restricted to cases where a considerable change can take place following the application of a relatively small amount of radiation. In the case of chemical synthesis, this situation pertains only in the instance of chain reactions where an active molecule triggers off the reaction of a large number of inactive molecules.

Polymerisation

An example of chemical synthesis is in the manufacture of plastics and is known as polymerisation. Usually the active molecule is provided by a chemical catalyst, which decomposes to give free radicals as they are called. Radiation can also act as a catalyst, but it differs from the conventional chemical types in that it can produce active radicals at almost any temperature. Chemical reactions can therefore be initiated over a very wide temperature range, and this may often result in a product which has physical properties quite different from those obtained under normal conditions. For example, polyethyelene, which is the plastics used in the manufacture of household buckets and bowls, is usually prepared by a process operating at 1,000 atmospheres pressure and 200 deg. C. On the other hand, the same process can be effected by radiation at room temperature and at 10 atmospheres pressure. The result of the lowered temperature of polymerisation is to produce a material which has physical properties different from those obtained at high temperatures.

Recently radiation has been used for the initiation of a new process, that of graft polymerisation. A polymer which is irradiated can either split off a side group or, alternatively, degrade into fragments. Whichever process takes place the net result is that an active centre is produced, either at the ends of polymer fragments or, in the case of polymers which split off a side group, at some point along the polymer chain. These active centres can act as focal points for the polymerisation of another monomer, so that if a mixture of a polymer and an entirely different monomer is irradiated, the net result is the production of a material which is made up of an initial polymer to which are attached chains of the added different monomer. Such a material is called a graft or block co-

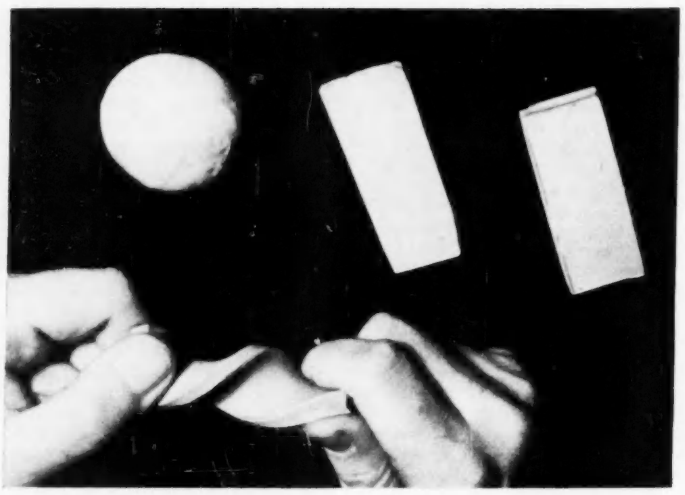

Fig. 3 Vulcanisation of silicone rubber. Linking of rubber molecules is effected by irradiation and not by means of sulphur atoms as in the conventional process. The ball on the left is unvulcanised. The quality of the rubber is indicated by its capacity to twist without cracking.

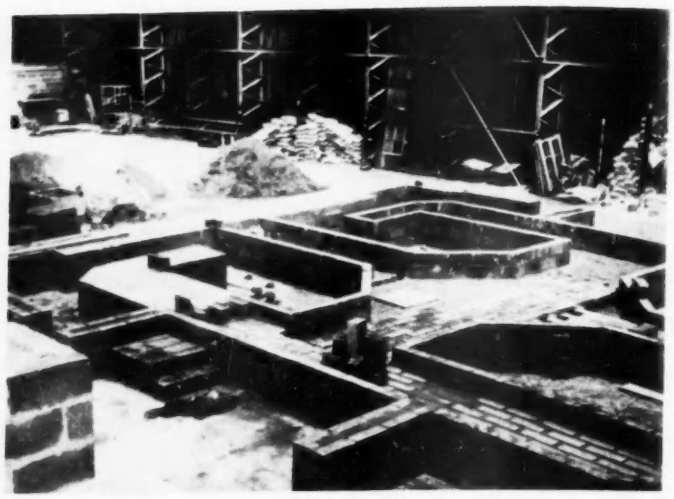

Fig. 4 Irradiation facilities under construction at the United Kingdom Atomic Energy Authority's research station at Wantage. The complex arrangement of entry passages necessary for shielding purposes can be seen in the illustration.

polymer and its physical properties are usually part way between those of the original polymer and the polymer formed from the added monomer. The process can obviously be used to produce materials in which the good properties of two different polymers are combined in a single substance.

Introducing New Physical Properties

Radiation can also be used to alter the physical properties of already manufactured materials. An example of this is the effect of radiation on polyethylene. In the case of polyethylene radiation causes the molecules to join together, eventually forming one large molecule. In this state, commonly known as a gel, the giant molecule can no longer melt, merely softening as the temperature is increased. After irradiation, therefore, the material can be used at much higher temperatures than before. The practical value of such a process may be gathered from Fig. 2. For example, polyethylene irradiated with a dose of 2×10^8 roentgens can be used at a temperature of 150 deg. C. for at least fourteen days. The process which takes place when polyethylene is irradiated is very similar to that which occurs when rubber is vulcanised. Usually vulcanisation of rubber is carried out using sulphur, the rubber molecules being joined together by chains of sulphur atoms. Irradiation can effect the same process with the difference that instead of the rubber molecules being joined by sulphur atoms, they are joined by bonds between carbon atoms. These carbon bonds are appreciably stronger than the sulphur bonds and therefore the rubber vulcanised by radiation should show an improved high-temperature performance. Although the amount of work which has been published in this field is as yet very limited, there are indications that the predicted high-temperature superiority of the radiation vulcanised material over that treated by conventional chemical methods has been obtained. Fig. 3 shows a ball of unvulcanised silicone rubber and strips after vulcanisation.

Commercial Exploitation

These examples are just a few of the possibilities for the use of radiation in industry. Most of them are still in the research stage, but their commercial exploitation will not long be delayed. We have seen that this is already being undertaken in the United States and advanced studies have been completed in this country. Fig. 4 shows a part of the Atomic Energy Authority's irradiation facilities at Wantage under construction. The intricate arrangement of entry passages, necessary for shielding purposes, can be seen from the illustration.

The chief uses for radiation are likely to be in the carrying out of processes which cannot be undertaken using conventional chemical or biological methods. Radiation will be an expensive industrial reagent and therefore the economics of its industrial use will be largely dependent on entirely new processes which can only be carried out using radiation. Sufficient results have already been achieved to indicate that the problem will not be the finding of new processes for using radiation, but rather the supply of sufficient radioactive material. It appears, therefore, that the fission products, far from becoming a liability to the atomic energy programme, will become, within the next few years, a most important industrial synthetic agent reaching out into many and varied fields of life.

Letters to the Editor

A NOTABLE TRACTION ENGINE

SIR, During the next few months, many of your valued readers will no doubt be spending a holiday in our delightful county, and for those of them interested in steam, there is a pleasure they must be sure not to miss.

I refer to the famous showmans' traction engine "Challenger," now owned by Mr. W. H. Jonas, Tudinnick, St. Issey, near Wadebridge. Built by Chas. Burrell of Thetford in 1904, this engine has just come through a boiler survey with flying colours. "Challenger" is mounted on rear wheels, 7 ft. by 20 in., and is a two-speed single-drive 8 h.p. double-crank compound tractor, having two injectors and pumps, a flywheel, and rim brakes on the rear wheels. She is heavily brassed, with a large dynamo, and weighs 18 tons. The length of her canopy is 22 ft. 6 in., and the height, from the ground to the top of chimney, 14 ft. Her maker's number is 2651. Next month "Challenger" will be travelling under her own steam to take part in the West of England Traction Engine Rally at Camborne on July 20.

Let us hope many enthusiasts will avail themselves of the opportunity of viewing this mammoth traction engine during the summer months.

Yours truly,
J. M. C. WINN.

5 Arundel-terrace,
Bude,
Cornwall.
June 9, 1957.

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TRAINING IN THE USE OF INFORMATION

SIR, There is correspondence in your issues of May 31 (page 679) and June 14 (page 740), indicating a worry that information services might make undue calls on the reserves of technologists.

I am quite sure from our own experience that trade associations and others can operate very good technical services by engaging erstwhile senior men retired from their professions. Not only can such men deal with inquiries, but they are likely to strike more personal relationships with their clients and to fish problems out which might not otherwise be forthcoming. There exists a great reserve of "young" retired men which might with advantage be of service to the nation, and one way of tapping this reserve might be in technical information services.

Yours faithfully,
H. M. WILSON,
Technical Secretary.

The Scottish Council (Development and Industry),
1 Castle-street,
Edinburgh, 2.
June 19, 1957.

Editor's Note: Another letter on this subject appeared on page 772 of our issue of June 21.

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Obituary

DR. J. F. ALLAN

Ship-roll Stabilisers and Model Experiments

Naval architects and shipbuilders throughout the world will learn with regret of the sudden death on June 8, of Dr. J. F. Allan, M.I.N.A., M.I.E.S., Superintendent, Ship Division, National Physical Laboratory, Teddington, Middlesex. The son of a Minister in the Church of Scotland, James Foggo Allan was born at Brechin, Angus, on July 23, 1904, and educated at Dumbarton Academy and the University of Glasgow. He served his apprenticeship with William Denny and Brothers, Limited, and from 1927 until 1929 held the Sir William White Research Scholarship of the Institution of Naval Architects. From 1926 until 1948 Allan was on the staff of William Denny's ship-model experiment tank at Dumbarton and during the last six years of this period he was in charge of this department.

In 1948, the year in which he was appointed Superintendent of the Ship Division at Teddington, Allan was awarded the degree of D.Sc. by the University of Glasgow for his pioneer work in the development of ship-roll stabilisers, now a familiar feature of many passenger ships.

Since Dr. Allan's appointment, the Division has considerably widened its range of activities and, under his enthusiastic guidance the new N.P.L. ship hydrodynamics laboratory, at Feltham, was planned and construction begun. The laboratory, which is to cost £2 million, is scheduled to be opened in 1959 when it will be one of the most comprehensive in the world.

Dr. Allan was known internationally in the field of naval architecture; he served on many committees and published a number of notable papers. He was a member of Council of the Institution of Naval Architects and of the scholarships and publications committee. He played a leading part in the organisation of the triennial International Towing Tank Conference (formerly the International Conference of Ship Tank Superintendents) and was an active member of several technical committees of the British Shipbuilding Research Association. Dr. Allan's published papers dealt with many different ship-design problems and one, on "The Stabilisation of Ships by Activated Fins," was awarded an I.N.A. Premium in 1945, and another, "The Effect of Roughness on Ship Resistance," presented jointly with Mr. R. S. Cutland to the North East Coast Institution of Engineers and Shipbuilders, last year, gained the M. C. James Medal.

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BRITISH ASSOCIATION

Meeting in Dublin

The forthcoming annual meeting of the British Association will be held in Dublin, from September 4 to 11 next, for the first time since 1908. Previous meetings of the Association in Dublin were held in 1835 and 1878. This year's President, Professor P. M. S. Blackett, F.R.S., has chosen "Technology and World Advancement" as the title for his address, which will be delivered at the inaugural session, in the library of the Royal Dublin Society, on the evening of Wednesday, September 4.

Preliminary arrangements provide that the work of the various sections shall commence on the following morning and, although the programme is not yet fully completed, it is expected that Sir David Anderson, the President of Section G (Engineering) will deliver his address to that Section on "Education and Training for the Engineering Industry," at that time. In addition to a number of papers by young engineers, communications are expected to be presented to Section G on energy and power supply; advances in aeronautics; rainfall, run-off, water supply and power; computing in the modern world; advances in telecommunications; and engineering problems associated with heat transfer. Subjects due to be dealt with under Section A (Mathematics and Physics) will include thermonuclear reactions, artificial satellites, the history of mathematics, and gravitational waves. Among the subjects to be discussed at other Sections may be mentioned urban land economics, agricultural economics, peat afforestation, economic development, United Kingdom trade in relation to the European free trade area, problems of international finance, science and industry, the functions of psychologists in the community, and perception in relation to skills and learning. Professor J. Greig, King's College, Strand, London, W.C.2, is the Recorder of Section G. Copies of the preliminary programme and other information may be obtained, without charge, from the secretary to the British Association, Burlington House, Piccadilly, London, W.1. An account of the papers presented at the meeting in Dublin will be published in our columns, in due course.

GAS IN THE ATOMIC AGE

The advent of the atomic power station with its prospect of cheaper electricity in the foreseeable future has provided a challenge to the gas industry, which it has not been slow to take up. The recent opening of a new extension to the Litchurch, Derby, gasworks marked a further stage in the modernisation programme which is being carried out in the industry, a brief review of which was given in the B.B.C. television programme "Behind the Headlines" last week.

At a cost of £4 million the Litchurch extension will provide an improved supply to eight counties in the Midlands. Improvements to the North Wales gas grid involved the laying of one hundred and fifty miles of pipeline, using up-to-date methods and equipment. Of particular interest was a machine for "bandaging" the pipeline with Fibreglass, a process which is carried out as the pipe is lowered into the ground.

In an interview, Sir Harold Smith, chairman of the Gas Council, spoke of the present and future activities of the industry. Whilst every effort is being made to use available sources of gas such as the waste, or "tail" gases from oil refineries, and methane from coal mines, the search for natural gas continues. An exploration programme costing about £1 million is under way, but has met with little success so far. The programme includes a geological survey, from which it is hoped to prepare an underground "contour" map of the country.

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Among those on whom distinctions have been conferred by Her Majesty in commemoration of her birthday, is Mr. William Scott, O.B.E., M.I.Mech.E., managing director of Armstrong Whitworth (Metal Industries), Limited, and chairman of Armstrong Whitworth and Company (Pneumatic Tools), Limited, who is created a knight bachelor for political and public services in Jarrow. Mr. Frank W. Townsend, experimental manufacturing manager to the Plessey Company, Limited, Ilford, Essex, has been made a Member of the Order of the British Empire. A fuller list of Birthday Honours appeared on page 775 of our issue of June 21.

NUCLEAR PROPULSION FOR MERCHANT SHIPS

Lloyd's Register Prepares

For the first time in the long history of the Society, the current annual report of Lloyd's Register of Shipping, just published, is issued in an illustrated form. The many photographs contained, it may be said, are well reproduced. They cover a wide field, ranging from examples of recently-built ships, like the survey vessel, John Biscoe, to the Dounreay atomic energy project, where the Society is providing shop and site inspection.* Also included in the report is a series of ten tables, accompanied in a few instances by coloured graphs, which indicate the great developments that have taken place in connection with the world's shipping during the past few years and provide examples of the Society's many activities. No less than 57 per cent. of all tonnage now under construction is being built to Lloyd's Register classification.

It is likely that, within the next few years, Lloyd's Register will be faced with the classification of an atomic merchant ship. The Society, it is stated in the report, is preparing for this responsibility by playing an active part in developments on these lines and by giving special study to those problems of the safety of marine reactors which will be essential to classification. For some years, it has been apparent that the development of nuclear power reactors for the generation of electricity and the propulsion of ships would be rapid, and that an early appreciation of the technical problems involved was essential. Accordingly, in 1950, the Society agreed with the Atomic Energy Research Establishment, Harwell, to provide an engineering advisory service in connection with an experimental project. Further, one of the Society's engineering surveyors was recently seconded to the Admiralty, for attachment to their atomic energy team on naval projects.

Possible lines of development for the propulsion of ships by atomic energy are receiving the serious attention of the shipping and shipbuilding industry, in co-operation with the Atomic Energy Authority. Long-term study and experiment to determine the practicability of an organic liquid moderated reactor for use in ships is being pursued at Harwell, in conjunction with the British Shipbuilding Research Association. It is hoped that the result will be the construction of a land-based prototype and that experiments with this prototype will lead to the building of a suitable nuclear reactor for ships. But a warning is given in the report that several years must elapse before this goal is reached. So far as the Admiralty is concerned, nuclear reactors are being developed for the propulsion of warships and it is possible, the report states, that the results of this work may also lead to designs which are suitable for the propulsion of merchant ships.

Discussing these sections of the report recently, Mr. H. N. Pemberton, the Society's chief engineer surveyor, emphasised the safety aspects connected with marine propulsion by atomic energy. He pointed out that the great danger in the use of marine reactors lay in the possibility of damage resulting from a collision. Because of this factor, the subject had received a tremendous amount of attention. If, he said, a marine reactor were put into a ship, it would be safe. The Society believed that it would soon be possible to plan a nuclear-propelled ship which would be acceptable for classification by Lloyd's Register. Replying to an inquiry as to whether the United States was ahead of Britain in respect to the planning of an atomic merchant ship, Mr. Pemberton said that such a position was possible, although it did not mean that the American ship would be an economic one. The ship that Britain "was planning rather than building was an economic one." No particular ship was being planned, but several types were under consideration.

It is announced that Mr. Kenneth R. Pelly, M.C., who has been a member of the general committee of Lloyd's Register of Shipping since 1937, has been elected to succeed Sir Ronald Garrett as chairman of the Society, as from July 1.

* An article on the John Biscoe appeared in ENGINEERING, December 7, 1956, page 718.

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ENGINEERING FOR GIRLS

In pursuance of their long-established policy of extending the opportunities for the technical training of girls, and their subsequent employment in engineering and scientific posts, the Women's Engineering Society is holding a week-end conference on the theme: "Careers for Girls in Engineering." The three main sessions will be devoted to technical education, industrial training and employment, and professional achievement; and they will be followed by an open discussion. Time will be allowed for informal talks and the interchange of ideas.

The conference will be held at the City of Coventry Training College, Coventry, on July 13 and 14 next, and a certain amount of residential accommodation will be available. Further information may be obtained from the headquarters of the conference, 26 Victoria-street, London, S.W.1. Telephone: ABBey 5481.

Weekly Survey

Cover Picture: *The tube shown in the straightening press in our cover picture is a typical example of a header tube used in large water-tube boilers. It is in the hot drawn state and is being straightened to enable accurate machining of the outside diameter to be carried out. This machining ensures uniformity of shell thickness and facilitates inspection.*

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Faster on Rail

These are stirring times for the railways. The faster, summer time-tables and the new faster trains to Scotland typify a number of changes which have come into operation in the past few weeks. Last week it was announced by the London Midland Region that a scheme for the decentralising of management authority had been put into operation, a step which is the subject of another note in this issue.

At the beginning of next month the new freight charges scheme comes into operation, and local traffic managers will have the opportunity at last to compete more adequately for traffic. In sum, big strides have been made with the modernisation of British Railways in the last two years. The modernisation programme, still scheduled at £1,200 million over 15 years, is now gathering momentum. Changes on the management side have been announced as well as the decentralisation programme for the two biggest regions. Mechanical aids are being increasingly introduced in offices and for the better co-ordination of control within districts, while progress continues to be made with the development of work study techniques. This last step alone may in the end be one of the most revolutionary in the modernisation programme. It may be small comfort to those involved that work study is gathering momentum within the organisation, but such is the case and its effects in the end are likely to be far reaching on railway re-organisation.

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Decentralising Railway Management

Steps towards a reorganisation of railway management on the lines proposed in the Transport Bill of 1953, and elaborated in the White Paper of 1954 on the Railways Reorganisation Scheme, were announced last week by the London Midland Region of British Railways. So far, they are concerned primarily with decentralising the Region's present arrangement of commercial districts responsible to a Chief Commercial Manager at Headquarters, and of operating and motive power districts responsible to corresponding superintendents at three divisional centres; and with setting up six geographical divisions each with a Divisional Traffic Manager. The managers will exercise their functions by means of the district officers of the Commercial, Operating and Motive Power Departments, and will be responsible to a Director of Traffic Services at headquarters, under whom the functions of the Chief Commercial Manager, Chief Operating Superintendent and Motive Power Superintendent have been combined. The six Divisions in the Region are to be based on London, Nottingham, Birmingham, Manchester, Liverpool and Barrow. These are not to be confused with the long-standing division of the Region for operating purposes into Western, Midland and Central Divisions, which correspond broadly to the territories of the former London and North Western, Midland, and Lancashire and Yorkshire constituents of the London, Midland and Scottish Group.

The new scheme is aimed at providing the direct and effective contact—so essential in competitive conditions—between traders, travellers and the railway all over the country. In its amalgamation of the interests of selling transport services and moving the traffic, it carries further the principles of enterprising business promotion, successfully developed by the commercial department of the L.M.S.R. before the war when in 1932 the railway created a post of chief commercial manager which was in effect that of the company's sales manager. This organisation flourished on a district basis under a chief officer at headquarters, but the greater administrative complexities of the present time, when the Region is part of British Railways, justify decentralisation in the interest of flexibility and adaptability. The divisions will eventually become self-accounting areas.

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Back to the Boom?

It would be churlish to belittle the excellent performance of exports in May. Provisional figures released earlier this month put them at the record figure of £315 million, including re-exports. Unfortunately, imports have also achieved a record level with the result that the adverse balance for the first five months of 1957 is significantly larger than in the same period last year. In so far as the increase in imports may be due to a modest increase in industrial stocks, the situation gives no cause for alarm. The rather dull conditions operating in non-ferrous metal markets remove some of the temptation which would arise to purchase heavy stocks on a rising market. On the other hand, if the rise in imports represents something of a spending spree by the public, following increases in wages, the situation has dangerous implications. There is no doubt that the economy is still too delicately poised to cope with rising exports, sustained capital investment and rapidly rising consumer expenditure all at the same time. It is such a state of affairs which the Chancellor of the Exchequer set out to avoid in his Budget in April.

So far as capital investment is concerned. the rate of increase has definitely eased off, According to provisional estimates put out by the Board of Trade recently, capital spending in the first quarter of this year was 10 per cent. higher than in the same quarter of 1956 but 16 per cent. down on the fourth quarter of last year. Compared with a year ago the major increase has been in building work, and even over the last quarter the fall in that category has been smaller than others. The big drop has been in vehicles where output is lower than both the first and last quarters of last year. Expenditure on plant and machinery over the first quarter of this year dropped by 15 per cent. Thus capital investment as a whole has been mainly sustained in the early months of this year by building work negotiated about a year ago. The number of factory projects approved in the second half of last year declined fairly severely and this may react unfavourably on building work later this year. Care will have to be taken that the year does not end with credit restrictions, a consumer boom and sluggish capital expenditure.

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Machine Tool Orders Recover

Deliveries by the machine-tool manufacturers during March were the highest of any previous month and there was some recovery in the booking of new orders. These increased by £1·16 million to £7·91 million and were the highest since February last year. Nonetheless, this is only a small first step, and orders booked during the first quarter of the year were £22·14 million compared to £25·54 million a year earlier. Deliveries in March continued to exceed total new orders and the industry's order book had fallen to £94·76 million, by about £2½ million in one month. This is very much in line with the pattern of capital spending by industry. The latest Board of Trade statistics, published recently, show a continued increase although the rate of advance is slackening.

The annual reports of machine-tool makers suggest a great deal more confidence than the Board of Trade's statistics. The chairman of the Expert Tool and Case Hardening Company, Limited, Mr. A. H. Redfern, said that the excellent progress made with the company's "major reorganisation, expansion and development plans" should in time result "in greater security and increased revenue." This emphasis on development was present in many other chairmen's reports. Mr. J. R. Greenwood, chairman and managing director of Craven Brothers, Limited, commenting on very unfavourable results due mainly to rising costs and the incidence of unfinished contracts for large special machines, said: "We shall expand our trading and within the present difficult conditions which are outside our control we shall continue to prosper." The company have three years work fully booked and see no slackening in demand. Kerry's (Great Britain) Limited, reported an increase in their sales of machine tools, Mr. E. Cassleton Elliott (the chairman) commenting that an "encouraging feature" was the receipt of orders from the United States. The general position of the leading makers was well summed up by Mr. Frederick G. Morris, chairman of A. A. Jones and Shipman, Limited, who reported very full order books and said that "given harmonious conditions in the labour field, we can look forward to a busy year."

The industry has work enough to await an upward turn in orders. There are signs that this may not now be long delayed. The introduction of new products and the technical progress made since the war suggest that the leading makers should more than hold their own in overseas markets.

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Export Shipments

The Shipping Conference System came under fire recently from Sir William Rootes, chairman of the Dollar Exports Council. On returning from a six months export promotion tour of North and Latin America, he is reported to have referred to the Restrictive Trade Practices Act in relation to the conference lines, and to have stressed the need for improved shipping facilities to Central American countries and the west coast of America. He went on to say that costs should come down and that the service the shipping companies can render to improve our export drive ranks among the major contributions that can be made to improve our overseas trading. As a result of the lag between the time the product leaves the factory in England and the time it reaches its destination, it is becoming very difficult to get our goods into Central America.

The general criticism of the Conference System has been refuted by Viscount Simon, president of the United Kingdom Chamber of Shipping who said that several official inquiries in the past had shown that the system is justified as the sensible and proper method of giving stable and regular services. This is perhaps the crux of the matter since stable and regular services, while desirable in themselves, may not always provide what the exporter wants. The solution may well lie in a retention of the Conference System coupled with greater flexibility in the provision of special and speedier services when required. As a case in point it has been announced that in order to meet the exceptional increase in exports of motor vehicles to America negotiations are in progress between the shipping lines represented on the North Atlantic Conference and the motor industry to provide additional shipping space. What is essential is that such negotiations should be put in hand in good time and not left until a shipping shortage

develops with all its consequent delays, irritations and possible lost markets.

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Pressure on United States Scrap Steel

Agreement has been reached between the United States Government on the one hand and the United Kingdom Government and the High Authority of the Iron and Steel Community on the Continent on the other to restrict the importation of United States steel scrap. The tonnages exported from America have been causing the Government in Washington some concern. This will probably involve a lost to the Community steel companies of about 400,000 tons of scrap. No figure is given of the expected cut in United Kingdom imports, but in both cases the loss is marginal. It remains to be seen if these cuts, which are quite modest in relation to total scrap consumption in both importing areas, affects the expansion of steel production over the summer.

With the completion of new blast furnace capacity in this country pig iron consumption has been growing more rapidly than that of scrap. In addition, the landed cost of imported heavy melting scrap at about £25 a ton is nearly double the controlled maximum price in the United Kingdom. On the Continent the effect of the cut is not expected to be very serious but it affects the Community at a sensitive point. Scrap users there pay a levy on purchases which is used to even out the price for the Community as a whole. The levy is changed in accordance with a formula based on each buyer's use of scrap for a given steel output and this arrangement has been challenged by certain steel producers. The decision as to its validity under the Treaty establishing the Iron and Steel Community is at present *sub judice*.

The trend of steel imports from the United States into western Europe, including the United Kingdom, has been downward for some time, but the recent recovery in the United States steel industry has put an added strain on supplies. The economics of the United States steel industry thus continues to play a significant, if no longer commanding, role in the steel-making activities of western Europe.

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Canada's Growing Market

In 1955 Canada provided about 9 per cent. of all United Kingdom imports and bought 5 per cent. of all United Kingdom exports. Canada thus ranked fourth to Australia, the United States and South Africa as an export market for United Kingdom goods. The trends in the Canadian economy and the prospects of increasing trade with the United Kingdom are discussed in detail in the latest economic survey of Canada, published by the Board of Trade last week, entitled *Economic and Commercial Conditions in Canada* by G. Bowen, C.M.G. (H.M. Stationery Office. 11*s.* 6*d.*).

The survey, including information up to 1955, shows that although since the 'twenties the ratio of imports to gross national product has declined, it has remained high; from 1951 to 1955 it was between 16 per cent. and 19 per cent. In actual terms, however, imports have expanded. In spite of the great growth of Canadian manufacturing industry over the past fifteen years, the share of imports in the total Canadian market for manufactured goods has increased, and the proportion of finished manufactures in Canadian imports is now as high as it was in 1929. Producer goods are assuming an increasing importance.

Between 1926 to 1929 and 1951 to 1954 the share of machinery and equipment in the twenty leading imports rose from 35·3 per cent. to 54·8 per cent. Imports of durable consumer goods such as refrigerators and freezers and heating and cooking apparatus also rose markedly between the two periods, and the expansion in these two categories has been mainly at the expense of non-durable goods. The Canadian market is therefore offering growing opportunities for the British engineering industry.

In addition to providing detailed information on the markets for particular goods, the survey draws some general conclusions of importance to the British exporter. Firstly, the Canadian market is growing both in value and variety of goods demanded. Secondly, and hardly less important, Canada, though now on balance an industrial country, still bases her economy on the exploitation of basic resources, and about a quarter of Canada's gross national income is derived from exports. There is a corresponding widespread goodwill towards imports. On the other side of the picture must be placed the powerful influence of the United States on Canadian standards, techniques and outlook, and the commanding position enjoyed by the consumer in Canadian business. The Canadian purchaser expects—and gets—a degree of service unknown to his counterpart in Britain.

The survey concludes that the Canadian market is so large and expansive, providing an increasing opportunity for the types of both capital and durable consumer goods which Britain can produce, that no progressive British manufacturer can afford to neglect it. Goods in this market will not, however, sell themselves.

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United States and Free Trade

To strengthen economic ties with other countries is the official American policy, stated in President Eisenhower's messages to Congress during 1957. It could have a major liberalising influence on international trade and greatly benefit Britain's exports, particularly those of engineering products. Nowhere does the President suggest that his Government should seek to dominate world trade. On the contrary, the promotion of American investment abroad is to be paralleled by vigorous United States support for the liberalisation of world trade and the cutting out of red tape in import procedure at home.

There is a recognition that multilateral negotiations have been more effective " in reducing trade barriers and discriminating restrictions against our exports " than any bilateral negotiations. During 1956 reciprocal tariff concessions involving about 1,000 million dols. of United States exports and imports were negotiated under the General Agreement on Tariffs and Trade (G.A.T.T.). The President has asked for legislation to authorise the United States membership of G.A.T.T.'s new administrative agency, the Organisation for Trade Co-operation, which is being created " to make G.A.T.T. an even more effective instrument for removing discrimination against our exports." Thus the pattern of the next few years is sketched out: investment abroad is to be increased.

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Active Service

Increasingly in the engineering industry there is a tendency towards the supply of a service rather than a product. The more successful firms in recent years have been those who have undertaken to supply a system of engineering, whether agricultural engineering, or instrumentation of factories, or the complete range of electrical plant in a manufacturing establishment. Plant users like to be able to contract out their whole needs to a firm able to plan and engineer the whole scheme. This has been done for years by companies such as Simon-Carves or Head Wrightson, but the practice is growing fast. Nuclear plant consortia have been formed expressly to bring together the knowledge and skills of reactor construction, steam raising, electrical generation and civil engineering which must be closely interrelated in any major project.

The application of modern techniques is becoming increasingly specialised, and more and more companies are setting out to provide a service as well as a range of products. An example of this are Foundry Services who sell fluxes to the foundry trade, but also advise on the use of these fluxes by making an analysis of casting techniques and results. Another is Weatherfoil Limited, members of the Powell Duffryn group of companies. Commenting on the need for " a manufacturing organisation able to advise on the diverse aspects of factory services " Weatherfoil have set up a co-ordinated technical service able to investigate the problem of air conditioning, space heating and process heating in order to produce a comprehensive scheme for which their manufacturing divisions and other companies in the group can supply the plant and equipment. Over ten years ago, the late A. P. Good had the same idea for the supply of " power engineering." It is a trend in industry which no manufacturing organisation can afford to ignore. From the users' point of view the more old-fashioned practice of retaining the service of consulting engineers and industrial consultants has much to commend it.

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Contractors Look Ahead

During the past few weeks there has been a marked revival in the rate at which inquiries for new projects have been received by the leading building and civil engineering contractors. The prolonged and disturbing lull in the flow of tenders which lasted throughout the Suez canal closure is now at an end. Moreover, the rate of output has been rising very satisfactorily, due partly to good weather and partly to the smoother flow of materials.

This cheerful state of affairs is reflected in the review of the past year's activities of The Limmer and Trinidad Lake Asphalt Company by their chairman, Sir John Hathorn Hall. Despite the " persistence of the credit squeeze " retrenchment in defence expenditure and rising costs, he foresees at least as good a result in the current year as in the past when trading profit was a record. While he considers it " unduly sanguine " to expect the rate of progress and expansion " to continue unchecked " he reminds his shareholders that " each year our more sober predictions are pleasantly falsified by the event." Mr. A. V. Bridgland, chairman of Humphreys Limited, sees no reason to fear the future " if the Government stands firm in its effort to improve our economy." Mr. C. J. S. King, chairman of Kinnear Moody (Civil Engineering), Limited, reports " a gratifying increase " in turnover and expects the volume of contract work to be maintained. Last month Sir Richard Costain commented that the solid achievement and good results of his company, Richard Costain, Limited, during 1956, should be improved this year but that " looking further ahead is much more difficult." Increasing foreign competition abroad and the prospect of a falling off in capital expenditure at home " unless the Government take action in time " marred the longer term outlook. This is a good summation of the industry's prospects.

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Sand in the Bearings

The fall in car output during 1956, has hit the manufacturers of bearings and produced a major re-orientation of product policy on the part of some companies. The chairman of the Glacier Metal Company, Limited, Mr. Wilfred Brown, indicated that the fall in gross profits on trading from £419,000 in 1956 to £291,000 was

due to the recession in motor vehicles. As a result, he said, the company are most concerned "because such a position contains a threat for the future." Glacier have been expanding their sales to other fields, particularly heavy engineering where demand has continued to increase. The research and development activities they have begun, yield "important information relating to the fundamentals of bearing operation" which will enable them to improve the design of bearings for large Diesel engines, turbines, compressors, etc.

British Timken have likewise found a strong demand for heavier types of bearings, which enabled them to achieve a turnover higher than the previous year and the highest in the company's history. They are now beginning to reap considerable benefits from the £3·3 million spent on expansion and re-equipment during the past five years. The lesson of fallingsales to the motor industry, whose own expansion plans played so large a part on those of bearing manufacturers, has not been lost on British Timken. Sir John Pascoe, chairman and managing director, said of the company's sales effort that it has resulted "in many more sales to other industries than the vehicle industry."

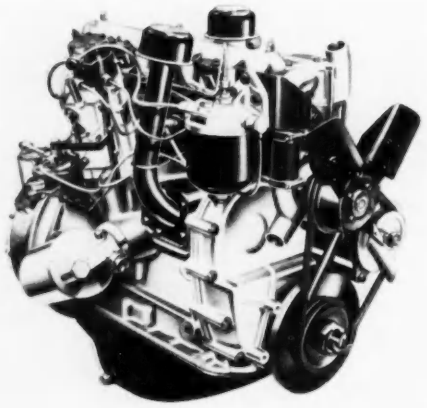
The same attitude could be read into the report of Mr. J. W. Garton, chairman and managing director of the Hoffmann Manufacturing Company, who were able to obtain "considerable orders for special bearings" and thus expand their turnover. Demand from the motor industry is now improving, but the way in which bearing manufacturers have been able to go ahead without it is evidence of the immense progress made in the use of bearings in engineering since the war.

DIESEL ENGINE FOR LAND ROVER

Water Cooled Unit of 52 b.h.p.

The attraction of the Land Rover will soon be increased for many buyers by the possibility of having a Diesel engine as an alternative to the petrol unit. In announcing the new power unit, which has been designed and built by the Rover Company with the collaboration of Ricardo's and C.A.V., Mr. L. G. T. Farmer, who was recently appointed joint managing director of the company, revealed that to date three-quarters of Land Rover production has been exported, and in less than nine years the car has earned just under £70 million in foreign currency. The Diesel engine is now being delivered on the home market and will be available in export markets from September. It is a two-litre four-cylinder unit with Ricardo Comet combustion chambers, and the new C.A.V. DPA single-cylinder opposed-piston injection pump. Maximum power is 52 b.h.p. at 3,500 r.p.m. and the speed range is similar to that of the petrol engine so that the same transmission units can be used. The maximum torque is 87 lb.-ft. at 2,000 r.p.m. and the compression ratio is 19·5 to 1. The maximum b.m.e.p. is 105 lb. per sq. in. and the bore and stroke are $3\frac{3}{8}$ in. by $3\frac{1}{2}$ in. The Diesel engine adds £100 to the price of the vehicle in Britain, before tax, and weighs 108 lb. more than the petrol unit. It gives about 50 per cent. more miles per gallon than the petrol engine.

The cylinder block has external stiffening ribs, and has a cast-in water gallery distributing the coolant round the removable wet cylinder liners. Overhead valves in the cast-iron head are operated by pushrods and rockers. Roller tappets are used, with hardened steel rollers in bronze shoes, which are lead and tin plated, to permit high valve lifts, and high rates of acceleration without excessive camshaft wear. Both main and big end bearings are thin shells of copper-lead with a tin overlay. The camshaft is driven by Duplex chain with hydraulic tensioner loaded by lubricating oil under pressure. Against the driving side of the chain is a rubber slipper to prevent whip. The pistons, of aluminium alloy, have three compression rings and one oil control ring, the top ring being chromium plated. Provision is made for fitting a second scraper to the piston skirt when the engine has seen long service. Connecting rods incorporate oil jets which spray oil on to the cylinder walls.



A new Diesel engine for the Land Rover develops 52 b.h.p. at 3,500 r.p.m., and is claimed to give about 50 per cent. more miles per gallon.

The new C.A.V. DPA pump is a single cylinder unit, based on an American design, in which opposed pistons are driven together by a cam ring. It is supplied with fuel by an A.C. mechanical pump, delivering at 5 to 8 lb. per sq. in. The injection pump is a compact air-tight unit, with no ball or roller bearings, and no highly stressed springs. It is lubricated by the filtered Diesel fuel. The same type of pump is used on the latest Ferguson tractor engine.

The injection nozzles are of the Pintaux type incorporating two jets, the auxiliary one spraying at an angle to the centre lines to assist a cold start. The engine is also fitted with glow plugs, and the injector nozzles are surrounded by heat resisting steel thimbles to protect them from the hot gas. Lubrication is by a submerged gear-type pump driven from the camshaft, and cooling is by pump and fan, with thermostat and by-pass.

When the full needs of the Land Rover production programme are met, the engine will also be made available for other purposes.

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AIR-COOLED DIESEL ENGINES

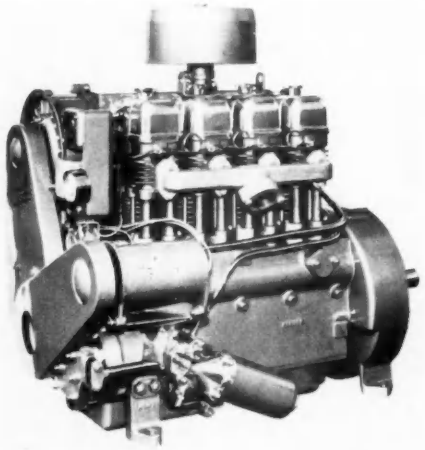
Industrial and Automotive Types

Two new ranges of Diesel engine have recently been introduced by Petters Limited, Staines, Middlesex. The earlier one which has actually been on the market for some little while, is the PH with single and twin cylinder units, which are generally similar to the earlier AVA range, but have an increased power rating. The PH1 single cylinder unit develops from 4 to $7\frac{1}{2}$ b.h.p. at 1,000 to 1,800 r.p.m. and the twin cylinder unit develops 8 to 15 b.h.p. at the same speeds. The cylinder bore of the new engines has been increased to $3\frac{7}{16}$ in., and the crankshafts are of more robust proportions, with larger bearings, to take the increased load. Many of the AVA parts are incorporated, facilitating servicing and spares holding. The PH1 engines are essentially intended for industrial and agricultural applications. General particulars are: vertical, air cooling, totally-enclosed overhead-valve type, working on the four-stroke cycle, using direct injection. Bore is $3\frac{7}{16}$ in., stroke 4·33 in. and the engines have a b.m.e.p. of 88·2 lb. per sq. in. at the twelve-hour rating. The compression ratio is 16·5 to 1. Aluminium alloy pistons are used with one scraper and three compression rings. The air cooling is obtained by a fly-wheel fan and the starting is by hand. Fixed and variable speed engines are available.

The second and more recent range comprises the PC high speed lightweight air cooled engines, and includes 1, 2, 3 and 4 cylinder models. The power output ranges from 5 to 20 b.h.p. for the different models, and all run at the comparatively high speed of 3,000 r.p.m. The high power to weight ratio makes them applicable wherever weight saving is important. They also represent the company's first incursion into the automotive field. The four cylinder engine has a specific weight of 25 lb. per b.h.p. They are "square" engines having a bore and stroke of 3 in. and work at a b.m.e.p. of 62 lb. per sq. in. The average piston speed is 1,500 ft. per minute, and the quoted fuel consumption is 0·52 lb. per b.h.p. hour.

The single cylinder model differs from the others in that it has a tunnel bore crankcase and a flywheel-type cooling fan, whereas the two, three and four cylinder versions have underslung crankcases and a high level axial-flow cooling fan.

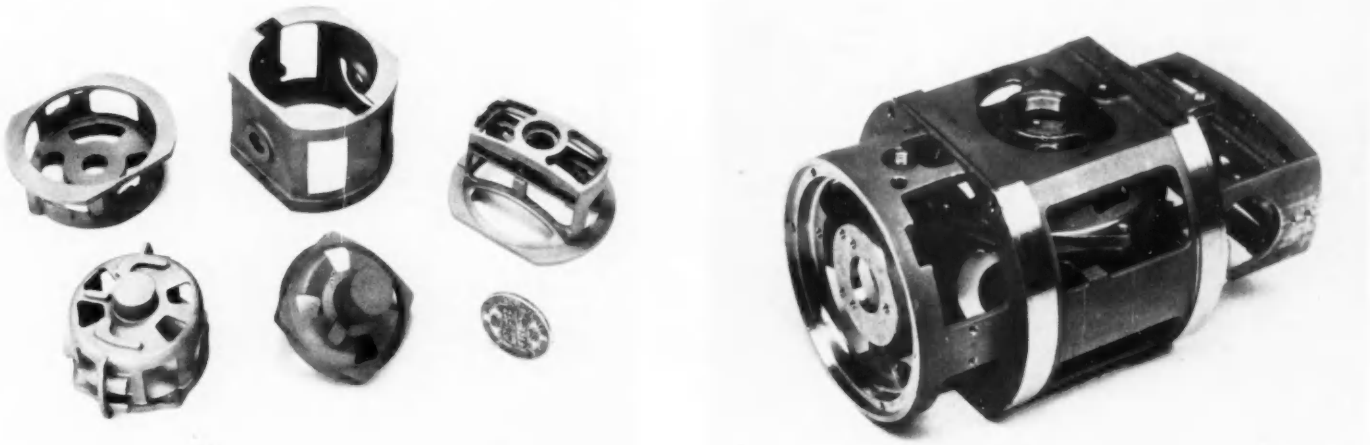
The crank cases are manufactured in cast iron, as also are the flywheels. Alloy steel crankshafts have been used with induction hardened bearing surfaces. Each crank throw is carried between two main bearings of the copper-lead thin-walled type. Low-expansion aluminium pistons have been used with fully floating gudgeon pins, and the top compression ring is chromium plated. The second and third rings are taper faced and the top scraper ring is chromium faced and split. The cylinder block is also made from cast iron, and is held in position by through bolts. The cast iron cylinder head has the ports arranged so that the exhaust gas leaves the head on the opposite side to the incoming air. Engine speeds can be controlled within B.S. 649 and may be varied by 10 per cent., up or down, by means of an external adjustment. Electric starting equipment is standard on the three and four cylinder engines, and the single and twin cylinder models



The PC range of high-speed air-cooled Diesel engines has a high power-to-weight ratio. The four-cylinder model shown here develops 20 b.h.p. at 3,000 r.p.m. and has a specific weight of 25 lb. per b.h.p.

can be started by hand from a half-speed shaft at the gear end. A half-speed starting device at the flywheel end can also be supplied. A range of clutches and gearboxes is available for fitting to the different models.

When used in traction plant, the engines can operate at large angles of tilt, using the standard sump. Longitudinal tilt varies from 25 deg. on the PC1 to 5 deg. on the PC4 and the radial tilt from 25 deg. on the PC1 to 30 deg. in a clockwise direction on the PC4—a figure reduced to 15 deg. in the anti-clockwise direction. Special deep sumps can be fitted when greater angles of tilt are involved.



Greater strength and rigidity are embodied in these investment-cast non-magnetic stainless-steel components of an artificial horizon instrument. These are shown on the left in the as-cast condition, with a half-crown piece to indicate their size. The finish-machined castings and final assembly are seen on the right.

HIGH-PRECISION CASTINGS IN STAINLESS STEEL

A recent achievement of Firth-Vickers Stainless Steels Limited, Sheffield, is the production, in high-alloy austenitic stainless steel, of the main structure of an artificial horizon instrument for use in high-speed jet aircraft.

The die-cast aluminium alloys formerly employed for this type of structure were ruled out in this case by the need for greater strength and rigidity. Steel cannot be die cast and the major machining difficulties involved were successfully overcome by the adoption of the investment casting process for producing the component. It is pointed out that an important advantage of the non-magnetic-steel investment-cast structure is an enhanced space-to-weight ratio. This improvement arises from the thin walls which were possible in the castings as now produced.

The individual component castings of the artificial horizon instrument are shown above in the as-cast condition together with a half-crown piece for the comparison of size. The finish-machined castings and their final assembly are also shown.

The dies used for the wax patterns, we are informed, were described by the makers as being "the most complicated we have made." Firth-Vickers Stainless Steels Limited, who manufacture an extensive range of stainless and heat-resisting steels and have considerable experience in the precision casting of these materials, are at present engaged on a variety of contracts for the aircraft industry.

RESEARCH ON STEEL FOUNDING

Some seven years ago, the British Steel Founders' Association established a Research and Development Division and, in March, 1953, a successor to this, the British Steel Castings Research Association, was incorporated. With headquarters at Broomgrove Lodge, Sheffield, 10, it commenced to receive financial support from the Department of Scientific and Industrial Research in April, 1954.

Owing to the continued development of the work of the Association it was decided, some years ago, to build a research station specially designed for scientific work on steel founding. In twelve months and at a cost of £93,000, laboratories, an experimental foundry and administrative offices, have been built and equipped, the whole of the funds needed having been accumulated out of revenue. The buildings, as stated by Mr. C. H. Kain, chairman of the Council of the Association, have been erected on virgin ground, and there is plenty of room on the site, which is in East Bank-road, Sheffield, 2, for future expansion and the building of additional structures. Actually, the present buildings have a total floor area of 12,000 sq. ft., and they occupy approximately half of the available site area.

Sir Harry Jephcott, chairman of the Council for Scientific and Industrial Research, who opened the new premises on June 4, said that the laboratories had a dignity and distinction of appearance that gave them that individuality which was bound to be a source of pride to those who worked in them. Inside, there was abundant evidence of wise planning and careful design. The buildings were indeed fit headquarters for a team of enthusiasts and he felt sure that the laboratories would quickly be established as an indispensable asset to the industry.

The experimental foundry occupies an area of 90 ft. by 40 ft., most of which is served by a 3 ton capacity floor-operated electric overhead travelling crane. Provision has been made for all essential foundry operations. Moulding-sand mixing, and core-sand and shell-moulding sand mixing equipment is provided, as well as a jolt-squeeze moulding machine, a core blower and facilities for hand moulding and core making. Mould and core-drying stoves and a shell-moulding machine are also installed.

Two electric steel-melting furnaces, one of 300 kg. (5 cwt.) capacity and the other a 30 lb. high-frequency electric furnace for the melting of a selected charge of material, are available. A high-speed immersion temperature indicator and recorder serves the two furnaces. The larger furnace is shown in the accompanying illustration. It is of the graphite-rod resistor type and is basic lined; it is heated by radiation from a horizontal carbon resistor fitted above the metal surface. When heated up from cold, the electrical input is 2,000 kW per ton and this drops to 1,400 kW per ton on a second heat and lower still for subsequent heats. For tapping and other operations the furnace is rotated on its axis by hydraulic means. Three-phase current is transformed to low-voltage single-phase current for the furnace, and temperatures of up to 1,650 deg. C. can be readily attained, the only limiting factor being refractory considerations. The furnace has been supplied by O. Junker, G.m.b.H., Lammersdorf, near Aachen, Germany. Its main advantages are that slag and steelmaking reactions can be carried out, that it is quiet in operation and has a tendency to consume any smoke produced, that there is a general absence of moving parts and that the capital and installation costs are stated to be lower than those of a high-frequency or a direct-arc furnace.

A ventilated stationary "Spenstead" knock-out grid, supplied by Spencer and Halstead Limited, Ossett, Yorkshire, is provided adjacent to the casting area. The fettling area is screened off from the remainder of the foundry floor and is equipped with a heavy power hack saw, a shot-blast cabinet, an air carbon-arc torch, welding equipments and pneumatic tools. Heat-treatment facilities, quenching tanks and other apparatus are available.

Well-equipped laboratories for the testing of

Graphite-rod resistor electric steel-melting furnace of 5 cwt. capacity being tapped. The furnace has a basic lining and is rotated about its axis by hydraulic means. The metal is heated by radiation.

sands, the analysis of steels and slags, and for microscopic and X-ray work are also provided, while in a building separated from the main structure is a dust laboratory devoted to the Association's work on airborne dusts in the field of industrial health. A test house containing a Denison 50 ton universal testing machine and impact and hardness testing and other machines and a machine shop, dark rooms, a library and information section, and administrative offices, occupy the remainder of the space in the various buildings of the research station.

PROGRESS REPORT ON ALZEN 305

Zinc-Aluminium-Copper Bearing Alloy

Some eight months ago, Hill, Alzen (Sales) Limited, Stringes-lane, Willenhall, Staffordshire, introduced into the United Kingdom a bearing alloy, Alzen 305, developed by the Austrian Vöest company. The new bearing material (described in an article in the November 2, 1956, issue of ENGINEERING, page 553) is claimed to have remarkable bearing properties, and to be considerably lighter in weight than phosphor bronze alloys. It is more readily machined and can be gravity and pressure die-cast.

On the basis of service experience and extensive laboratory tests, the distributing company have issued a development report, extracts from which we give below.

The alloy has been tested and used over a wide range of applications from small high speed bearings running at 1,500 ft. per minute with bearing pressures of up to 200 lb. per sq. in. to large highly-loaded bearings running at 200 ft. per minute with bearing pressures of up to 5,800 lb. per sq. in. The tin-bronze bearing alloys can successfully be replaced by Alzen 305 except where (*a*) operating temperatures are consistently in excess of 150 deg. C.; (*b*) there is a possibility of corrosion by salt water, acids or alkalis; and (*c*) a bearing clearance less than 0·0015 in. per in. shaft diameter is required.

Continuous cast alloy is now available in solid bar from 1 in. to 2½ in. in diameter. The physical properties in this form are superior to those in any other cast condition and bearing tests have proved that bearing life is also superior.

Tests on pressure die castings have revealed one serious feature, the fact that the alloy in the pressure die-cast state is subject to a growth of 0·003 in. per in. after ageing. This growth was found to be the result of phase-change suppression, and heat treatment obviates the fault. The results of the tests were submitted to the Zinc Alloy Diecasters Association, which body saw fit to recommend to the British Standards Institution the inclusion of Alzen 305 in the range of zinc base alloys suitable for pressure die casting. The decision of the Mark Committee of the B.S.I. is now awaited.

Approximately 30 per cent. of the production in Austria is sold in extruded form. The physical properties of extruded material are exceptional, the tensile strength being 30 to 35 tons per sq. in. and the elongation 12 to 20 per cent. Coupled with the high mechanical properties, the bearing qualities of the alloy are not impaired by hot or cold working. In the United Kingdom, any company equipped for producing extruded material may purchase the alloy in either billet or ingot form from Hill, Alzen (Sales) Limited who in turn will supply all the necessary information on the technique, which results in worth-while savings in machining time and prime material cost.

Alzen 305 can also be manufactured in the form of hot-rolled plate for use as slides in planing machines, drop-forging hammers, keeper plates of rolling mills and guide bars for various machine tools. The mechanical and bearing properties are similar to those of extruded material.

The alloy can be readily forged utilising a forging temperature of 270 to 280 deg. C. The main uses for forgings are for worm wheels, connecting rods, screw boxes and gears.

Tests are at present in progress relating to the production of sintered Alzen 305 material for producing self-lubricating bushes. To date, Alzen 305 in powder form has been successfully manufactured and work is being carried out to develop the technique of pressing the powder into bushes.

The alloy has been successfully lined with white metal and the bonding found to be satisfactory. The main advantages of Alzen over copper-based alloys for support housings for white metal bearings lie in the fact that the thermal conductivity of 0·24 0·27 Calories per sq. cm. per sec. per deg. C. is almost double that of the tin bronzes. In addition, the mechanical properties of Alzen 305 render it a satisfactory material in this application.

Alzen 305 has been extensively used in worm wheel and gear applications in both the chill cast and forged states. Tests have proved that the wear on Alzen worm wheels can be as little as one tenth that of bronze. The tendency for pitting occurs at a relatively lower load than for bronze but the rate of wear is considerably less. Operating temperatures for worm wheels should not exceed 100 deg. C.

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LIGHT-WEIGHT METAL DETECTOR

A portable light-weight metal detector is being put on the market by Metal Detection Limited, Moseley-street, Birmingham, 12. The "Transitect" weighs only 4 lb., including the supply batteries which are housed in the handle section of the unit. Transistors are used in the circuit. A grip switch also housed on the handle affords the on/off control and the circuit can be set up for varying conditions by three controls provided. In operation the unit is passed over the surface of the object in which metal is suspected, and the oscillator volume as produced in the earphones increases as the detector passes over metal. Operations include detecting metal reinforcing in concrete, hidden metal roof supports in mines and other similar applications.

When the Transitect is passed over an object the presence of metal is indicated by a change of note in the earphones.

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LUBRICANTS FOR ATOMIC APPLICATIONS

One of the side line problems encountered in the development of nuclear power plant has been that of producing a lubricant which is not damaged by radiation. Most of the normal types used on ordinary machinery rapidly harden under continued radiation, becoming jelly-like and therefore quite unsuitable for circulation. The Shell Research Centre, Thornton, Cheshire, in collaboration with the Atomic Energy Research Establishment have been working on this problem for some time, and have produced a range of lubricants which will be known as the Shell Atomic Power Lubricants (APL), which will stand up to continued radiation without deterioration.

To do this research, a special chamber was built at Thornton in which samples of lubricants could be irradiated from a cobalt 60 source. However, this emits gamma rays only and consequently it was necessary to carry out some experiments in collaboration with Harwell, where some samples were inserted in a nuclear reactor for subjection to neutron flux at about 10^{12} thermal neutrons per sq. cm. per sec. together with associated fast neutrons and gamma radiation.

Other requirements of lubricants in nuclear power stations are that they must have an extremely low vapour pressure in order to avoid any possible contamination of a reactor, and, in some cases they must also be capable of withstanding high temperatures for long periods. Indeed, in certain instances, it may only be possible to renew the lubricants after several years. With this type of reactor, there is also the problem of the compatibility of the lubricant with the hot cooling medium which, for example, may be carbon dioxide under high pressure.

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NO-PAINTING QUALITIES OF ALUMINIUM CONFIRMED

Unpainted aluminium rolling stock has been found to be a successful proposition on London Transport's underground services. Trials with single coaches have encouraged the Executive to proceed further and soon three prototype trains of unpainted aluminium coaches—devoid of their familiar red paint—are to go into service. Based on the experience with the new trains (some other innovations are being made as well as the absence of paint), substantial orders will be made for rolling-stock replacements.

Though the initial cost of the new stock is higher than that of the all-steel carriages, this will be comfortably offset by a substantial saving in painting—labour as well as 5 cwt. of material on each car—and in maintenance generally throughout the working life. Altogether, a considerable economy will be effected. The saving in weight in each coach, however, is only about 1 ton compared with the standard 1938 stock for either motor coaches or trailers because a steel framing has been retained. Nevertheless, even this saving in weight, representing about 4 per cent. of the gross, will contribute to a smaller power consumption both on starting and on rising gradients. The endurance of aluminium panelling under railway conditions should give no cause for alarm. A Southern Region unit is still in service 47 years after it was built and some coaches dating from 1916, constructed for the Manchester-Bury line, have recently been found to be in better condition than some steel-panelled cars of the same vintage.

The first of the prototypes is now being completed by the Metropolitan-Cammell Carriage and Wagon Company, Birmingham, and the other two by the Gloucester Railway Carriage and Wagon Company and the Birmingham Carriage and Wagon Company. Among the other changes being made are rubber suspensions (instead of steel springs) to give smoother riding characteristics; new-style interiors with contemporary upholstery and end partitions in colourful birds-eye maple plastics; "sun-tan" fluorescent lighting giving better illumination than hitherto; and only "facing" seats, instead of the mixture of facing and non-facing seats which some passengers do not appear to like.

British Electrical Power Convention

ELECTRICITY SUPPLY AND PLANT

A USER'S CRITICAL COMMENT

Few people will be prepared to dispute the fact that the electrical industry, with its vast nuclear and conventional power station building plans, railway electrification projects, defence programme and generally bulging order books is enjoying a boom period and has every right to a feeling of pride and satisfaction in its achievements in the post-war period. These sentiments can be detected as a theme running through the papers read at the British Electrical Power Convention held at Eastbourne this week.

While those at the receiving end of the electrical industry, namely the general public and those responsible for buying and running electrical equipment in factories, etc., are fully aware of the benefits which accrue from the use of electricity, they may reasonably offer some constructive criticism.

In a paper entitled "Electricity Supplies to Industry," Mr. C. T. Melling of the Eastern Electricity Board dealt with the economic and commercial aspects of electricity supply. The supply industry is to be congratulated on the relatively low increase in the cost of generation and distribution of electricity which has taken place since 1938 in a period during which the cost of fuel has risen 350 per cent., wages and salary rates 200 per cent., capital equipment 200 per cent. and cables, etc., by 300 per cent. A rather less palatable fact is that it is evident that generating plant will be barely adequate to meet growing needs for many years to come, in spite of the considerable effort and expenditure which has already taken place, plus that projected for the future. It seems, therefore, that industry will remain at the mercy of the winter weather for some while longer, and in the circumstances the more tolerant view shown of late towards private generating plant is both prudent and welcome.

It is clear that the supply authorities are acutely aware of the desirability of improving the system load factor and to this end efforts are being made to induce industry to adopt shift working to a greater extent and also to instal equipment using "off-peak" power. Industry is of course also aware, via tariffs, of the need to improve load factor, but since the cost of electricity forms probably only 3 to 5 per cent. of the cost of manufacturing many articles, the economic advantages of a lower electricity bill may be well outweighed by social and economic disadvantages. Similarly any arguments used to persuade manufacturers to use "off-peak" power by the use of heat storage systems, etc., must be based on hard economic fact.

Special tariffs must be sufficiently attractive to make worth-while the excess capital expenditure normally involved. All too often the tariff may just cover the additional expenses without leaving sufficient margin to justify a change of existing equipment which may have many years of useful life remaining.

A further paper read at the meeting entitled "The Selection, Installation and Maintenance of Electrical Plant in Factories" by Sir Henry Clay and Mr. G. Ovens, surveys this field through the eyes of the consulting engineer. The early part of the paper dealt with the many possible ways in which a project may be engineered and listed the persons involved in the different methods as follows:—

(*a*) Maintenance engineers of the smaller industrial firms.

(*b*) Development department of the larger organisations.

(*c*) Electrical manufacturers working with a virtually free hand.

(*d*) The Electricity Boards.

(*e*) Consulting engineers.

A comparison based on the total number of projects being carried on at this moment would undoubtedly show that most of them are being jointly engineered by the maintenance staff and the manufacturers in the case of the small firms, and by the development departments and the electrical manufacturers in the case of the large organisations.

It is certainly true that the maintenance engineers by their pre-occupation with existing equipment will often have a restricted outlook, that electrical manufacturers exist to sell their own equipment and that development departments often do not see eye-to-eye with the outlying factories, but notwithstanding these facts, most of the project work is engineered by these parties.

Much of the trouble encountered in factory development lies in the appreciation of the problem followed by the conception and specification of the solution. Where no development department exists the consulting engineer should be ideally placed to be of assistance. However, in the main the consulting engineers are engaged on the larger projects to the exclusion of other work. In the case of the smaller consulting engineering firms, too few specialists are employed to cover the very diverse requirements of modern industry. Generally speaking the Area Boards do not carry a large staff to deal with consumer engineering problems and largely confine their activities to the supply and sale of electricity. It is apparent, therefore, why more and more industrial concerns are increasing their engineering staff, or forming development departments, as only in this way can they obtain appropriate technical advice.

Problems of course exist beyond the point where a project has been specified. These problems could be summarised under the following headings: delivery; price; service and maintenance.

The question of delivery periods is a delicate one, and with waiting periods still in the region of twelve months for many items of even fairly simple nature, there is, of course, much room for improvement. Regrettably, also, the overdue delivery still plagues us—it was mentioned at the Convention.

On the subject of prices, one is usually faced with one of two alternatives. Either quotations will be received from several sources all agreeing to the nearest penny, or else quotations to a tight specification may be received which vary widely. An instance of the latter came to light recently when three manufacturers of about the same size and standing quoted £2,400, £2,600 and £3,200 respectively, for the same quantity of precisely specified control gear.

Maintenance of electrical plant, as with other plant, is becoming a severe problem in a modern factory and it is clear that as the drive towards the automatic factory is pursued the problems posed by its maintenance will become more acute.

Taking as an example a medium-sized steel tube mill, we might find the following included among its electrical equipment:—

(*a*) H.T. and L.T. supply and distribution gear, transformers, switchgear, metering, etc.

(*b*) Compressor drives for pneumatic and hydraulic services.

(*c*) Drives for various processes comprising both small and large motors, some supplied at elevated voltages. Associated control gear.

(*d*) Special drives, such as variable speed, possibly involving mercury arc or Ward Leonard equipment.

(*e*) Resistance and induction furnaces with their metering and control equipment.

(*f*) Electroplating plant.

(*g*) Welding equipment.

(*h*) Large quantities of sequencing and relay/contactor equipment.

(*i*) Electronic equipment used in servo control, etc., and measurement.

(*j*) Punched tape and card control equipment.

(*k*) Electric lighting gear of all types.

It is evident that a firm will find it difficult to employ specialists to cover maintenance of all the items of such a diverse list and therefore individual maintenance engineers will be expected to have a reasonable knowledge of several types of plant. Maintenance of industrial electronic and light current equipment remains difficult and is inadequately covered in many factories employing this type of plant.

The electrical industry can obviously assist in this respect by providing more robust and reliable equipment, with fewer components of strictly limited life. Increased use of static switching elements of the transistor and magnetic amplifier type would give benefit, as would the elimination of the industrial use of the 3000 type relay. This relay was developed for communications use in clean atmospheres, and its use under conditions of vibration, dirt and fumes, coupled with a usually more active duty, is to be deplored.

Servicing facilities offered by manufacturers vary considerably, with all but a few realising that their reputation is at stake. The few might well take a lesson from the many and take steps to bring their service organisations up to a satisfactory level.

BUSINESS WITHOUT PATERNALISM

The 1957 British Electrical Power Convention was opened at Eastbourne by the presidential address of Sir Josiah Eccles. Recalling that nine years ago he had made, at Eastbourne, the valedictory presidential address of the Incorporated Municipal Electrical Association, he pointed out that the present convention, through the inspiration of Lord Citrine and with the co-operation of the electrical industry, had risen from the ashes of that and kindred associations and had become a focal point of contact for the industry.

"This is a comprehensive and key industry, and as such we are entitled to take a comprehensive view of our responsibilities and the impact of world affairs upon our progress." This sentence set the key of Sir Josiah's address. During an extended survey of the economic events of the last nine years, he spoke of the Government's financial policy. He said that, making full allowance for the nature of the Government's problems, the industry was entitled to require from them that "their policy should be made known and be as stable as possible for as long as possible so that industry may be enabled to plan their enterprises on a durable foundation." Then, turning to the present, he said: "We can and will succeed in maintaining our relatively high standard of living to the extent that we unfetter native genius, equip ourselves to use it, pull together as a people, discipline ourselves to the necessities of the case, control our destiny by conscious effort and attune our way of life to the changing circumstances.

"Perhaps the greatest need is for everyone to realise and understand our problem. This done, the next greatest need is to secure the maximum degree of co-operation from all sections. As an educated democracy we are inclined to engage in controversy . . . in circumstances where there is room for sectional interests to score points without doing serious damage to the national economy, it adds interest to life.

"In my judgement, however, those circumstances are passing from us and there is need for an increasing amount of understanding and goodwill . . . The ideal is that each business organisation, whilst rejecting paternalism, should

become more of a family concern in the sense that all are partners and all working for a common purpose." In his opinion the employing organisation must take the lead in these matters. Sir Josiah discussed the problems of the British industrial democracy in some detail and then went on to examine the manner in which the electrical industry was facing present-day problems. He said that the papers presented at the convention showed how the industry was discharging its duties. Not wishing to traverse the ground covered by the authors, he restricted his remarks to general observations.

He mentioned recent technical achievements and the increased rate of installation of plant. As an illustration of the latter fact, he pointed out that in each two weeks in 1956 new generating capacity equal to the full output of the Calder Hall station was placed in service. In speaking of nuclear power he suggested that unless there was a substantial reduction in the real capital cost of nuclear stations, the rate of investment might be the limiting factor on the speed of nuclear power development. He saw the present programme as a pioneer development, and as a kind of chain reaction whereby the early stations manufacture some of the fuel needed to operate the later less expensive designs. He also saw it as a demonstration and a shop window that showed that Britain was prepared to play the same role in the second industrial revolution as she did in the first.

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BOILERS

In the paper "The Contribution of the Boiler Making Industry to the Economic Development of Electrical Power Generation," Mr. W. F. Simonson remarked that to obtain the thermodynamic gains from advanced steam cycles a large turbo-alternator was required; while in order that maximum economy, both in overall capital costs and in operation, might be achieved, the associated boiler plant must be concentrated in a single unit. Post-war development in the industry had been directed to this objective. Of particular value to the economics of power generation had been the incorporation of a reheater in the unit boiler. In the large boiler-turbine unit, not only were pipework arrangements greatly simplified, but the reheater duty was directly related to the heat input to its associated boiler and superheater, and operational control was thereby facilitated.

The contribution of the large unit boiler to the overall economy in capital costs was substantial, the heavier scantling and special alloy steels necessitated by the advanced steam cycles being offset by the economies in labour and materials resulting from the concentration of output in a single unit. In consequence, the volume occupied per kilowatt installed decreased from 26·6 cub. ft. with 30 MW sets to 16·7 cub. ft. with 200 MW sets, unit boilers being used in each case. The larger unit afforded appreciable economies in operating man-power over a combination of smaller boilers of the same overall steaming capacity, since automatic combustion control became a virtual necessity. In fact, both the operating and maintenance staffs of one large boiler were little more than half those required for the equivalent capacity with two boilers.

Availability was a primary consideration in design. With advancing steam cycles the actual evaporative duty of the boiler was progressively reduced and was fulfilled almost entirely by radiant heat transfer. Contributions to high availability were the absence of refractory surfaces and the provision of widely spaced tube elements in the plate or curtain wall types of construction of superheater and reheater, thus facilitating on-load cleaning. The extensive welding now employed in casing construction minimised air infiltration and reduced stack losses. The pressurised furnace was being developed to obtain further economy.

In a paper on "The Contribution of the Turbo-Alternator Manufacturers to Technical Advancement and to the National Economy," Mr. L. S. Robson pointed out that with economic pressures and temperatures the capital cost of stations per megawatt installed fell steadily as the unit ratings increased. For 200 MW units the capital cost per MW installed was about two-thirds of that for 30 MW units. Economic pressures and temperatures increased with unit ratings and for reheat plant were slightly lower than for non-reheat.

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NUCLEAR POWER

Excluding fuel charges, the capital costs of the first nuclear power stations stand at about three times those of conventional stations. On conventional stations in Britain it is usual to amortise capital charges over 25 years for plant and 40 years for buildings and civil works. The assumption being that it is better to replace plant, or give it a major overhaul, in existing buildings rather than build a new power station. The same policy will not be adopted for nuclear power stations. The whole plant will be amortised over the estimated useful life of the reactor. Designs of reactors and turbines are likely to get a lot better—it is unlikely that a present-day reactor will be duplicated at the end of its life to keep the installed turbines in use.

In a paper "Nuclear Energy in Great Britain," Mr. J. C. Duckworth and Mr. W. H. C. Pilling said that a reactor could be expected to last for 20 years. This period would be taken as the amortisation period for the whole plant. The authors also held that it was unlikely that the reactor life would be limited by effects at present unknown. But lack of previous experience limited the accuracy with which known effects could be predicted. They suggsted that the lifetime would be limited by one of the following: deterioration of the graphite structure; deterioration or distortion of the pressure vessel; deterioration of the concrete biological shield.

Efforts are being made to reduce the high capital costs. Two methods seem possible in gas-cooled reactors—increasing the heat-rating of the fuel, and working at higher temperatures. The authors expect beryllium to play an important part in both methods. Mentioning other types of reactor, they considered that the trend was towards increased enrichment of the fuel and decreased core size. The two features lower capital cost but make for more difficult engineering problems.

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POWER STATIONS

Mr. F. H. S. Brown and Mr. E. S. Booth presented a paper on "Coal and Oil-Fired Power Stations" in which they emphasised the importance of siting new stations in low fuel cost areas and summarised the technical requirements of those sites for both coal and oil-fired plants. To date the Central Electricity Authority had been reasonably successful in their search for such sites.

The only important source of cooling water in the East Midlands was the River Trent, which bordered on the coalfields. Here it had been possible to instal a chain of major new stations with a total installed capacity of about 5,000 MW. In the North East and in South Wales, where the coalfields were on or near the coast, the principal sites being developed took water from estuaries.

No new stations had yet been designed for burning oil only, although four (at Belvedere, Northfleet and West Thurrock on the Thames and at South Denes on the East Coast—a total capacity of 2,440 MW) had been started with no equipment for burning coal. It was intended that they should be capable of conversion from oil to coal in from 18 months to two years should the fuel position warrant the change. Meanwhile, investment in costly coal handling and burning equipment had been deferred.

The ratings of the largest unit so far developed had not been sufficiently high in relation to the total capacity of the British system to raise any insuperable difficulties of flexibility or security. The normal expectation for the immediate future could therefore well be the further pursuit of the economies from higher unit rating, coupled with rises in steam conditions. Nuclear power, however, made it virtually certain that conventional installations would soon have to be planned for lower load factors than hitherto, and essentially for two-shift operation. That would inevitably mean some slowing down in the rate of advance in steam conditions for the conventional installations and an adjustment of outlook on plant development to take into account a whole series of new factors.

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SWITCHGEAR

Mr. C. H. Flurscheim presented a paper on "Transmission Switchgear for 132 kV and Higher Voltages," in which he pointed out that the increased requirements of high-voltage networks during the past 25 years had been met by new types of oil circuit-breakers and by the introduction of the air-blast circuit-breaker. The oil circuit-breakers initially installed on the 132 kV grid in Great Britain had either multi-break plain-breaker contacts or early patterns of arc-control interrupters. Their rupturing capacity was equivalent to 1,500 MVA and the total break time was usually 8 to 10 cycles. They had earned a good reputation over a long period of years. Some had been reconstructed after 25 years' service and were now re-rated for 2,500 MVA.

In 1946 dead-tank bulk-oil and air-blast circuit-breakers of the same rupturing capacity were installed, and these designs had since been developed—during 1956 several had been uprated to 5,000 MVA. Since the war the rupturing capacity of British circuit-breakers had risen more rapidly than the voltage. By 1953 the rating of the circuit-breakers for the British 275 kV grid was as much as 500 MVA, and in 1956 units with a rupturing capacity of 12,500 MVA had been supplied for a 220 kV system in Canada. Designs were now available for circuit-breakers having short-circuit ratings, based on British standards, of up to 15,000 MVA at 330 kV and 20,000 MVA at 400 kV.

With the test plants available it was not possible to do full-scale tests on a complete three-phase circuit-breaker for the highest rated voltages and rupturing capacities. This had led to designs with a number of breaks in series being universal for the highest ratings, as this permitted the adoption of "unit testing," whereby one or more of the breaks were tested at the rated short-circuit current and the appropriate share of the voltage.

A paper, "Power Station and Distribution Switchgear," was presented by Mr. J. S. Cliff. During the post-war years the general trend in the design of switchgear had been directed to achieving increased reliability coupled with savings in materials and maintenance costs. As a result, new national standards had been introduced and the technique of short-circuit testing had been considerably advanced.

It was becoming increasingly common to use 6·6 kV and 11 kV for the auxiliaries in the larger power stations, and it was essential that the associated switchgear should have a very reliable short-circuit performance. As a number of the circuits were operated at currents approaching full load for long periods, the contacts must not deteriorate and must also have a long life when subjected to a considerable number of switching operations.

In modern power stations, the medium-voltage

circuit-breakers were exclusively of the air-break type, as the space factor was very much better than that of oil circuit-breakers and the contacts also had a longer life.

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TRANSMISSION

In a paper on "The Economic Aspects of High Voltage Transmission," Mr. F. J. Lane and Mr. W. Casson said that although Britain's high-voltage transmission system had been planned primarily for the pooling of spare generating plant, and had been fully justified economically for that purpose, it had also made possible the selective loading of the plant, the economic location of new generating stations, the use of larger units and the integration of nuclear generation.

Some conception of the order of saving in fuel cost attributable to interconnection could be obtained by assuming that without it all generating stations would be running at the same nominal load factor. A comparison of the fuel costs during 1953-54 and 1954-55, estimated on this basis, with the actual fuel bill indicated that there was a saving due to interconnection of about £25 million per annum, or rather more than 15 per cent.

Most of these savings were due to interconnections within the regions, but in the years immediately ahead there were prospects of much larger operating economies owing to the provision of 275 kV interconnectors between the regions for the pooling of reserve plant. In 1956-57 exchanges of energy between England and Scotland alone had saved more than £250,000; and by 1960, with the 275 kV system as now planned in full commission, savings in the cost of fuel in excess of £3·5 million per annum should be achieved as a result of economic transfers of energy between regions.

Of this saving of £3·5 million, £2·5 million would be due to the location in the Midlands coal-producing areas of part of the new generating plant capacity required to meet the demands in the coal importing regions in the south. For this purpose extra transmission capacity was being provided at the comparatively low estimated cost of £9 million at 1952 price levels. In 1960 the net annual saving due to the economic location of generating plant in this way would be about £1 million.

Yet another advantage of high-voltage transmission was that it permitted the use of larger and more advanced designs of generating plant, with resultant savings in power station capital and operating costs.

The effect of the Government's nuclear plant programme would, however, be to reduce these transfers of energy from the north to the south, as it was the general intention to site the stations as near as possible to the major load centres.

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TRANSFORMERS

In a paper on "Developments in Transformers for 132 kV and Higher Voltages," Mr. E. C. Rippon reviewed the developments which had taken place in the design and manufacture of extra-high-voltage units since 1949. Transport was one of the major problems which had to be taken into consideration, and in general all the transformers for the 275 kV grid had to be designed so that they could be carried by road, where the limitations of rail carriage and coastal shipping were not encountered.

Transport considerations did, however, limit the rating of the three-phase transformers that could be carried; and any increase in this could only be achieved by raising the operating flux density of the core. The development of cold-reduced grain-oriented electrical sheet-steel enabled higher flux densities to be employed without detriment to the core loss. In fact, any increase in flux density for given core size provided a proportionate increase in rating for the same total weight. On the other hand, although these higher operating flux densities would permit the transport of larger transformers, attention would have to be paid to the magnitude of the magnetising current and to the reduction of the sound level in situations where this was of importance.

"Distribution Transformers," by Mr. S. Z. de Ferranti, dealt with units with outputs from 5 kVA single-phase to 1,500 kVA three-phase at voltages up to and including 33 kV for use at 50 cycles. The introduction in 1951 of the specification T.1 of the Transformer Standardisation Sub-Committee of the BEA/BEAMA Joint Committee had had a progressive effect on the design of such transformers by allowing the resulting standard designs to be closely studied during manufacture and by type testing. As a result, electrical and mechanical design manpower had been released and applied to the original and more difficult designs required for specialised applications. The supply of transformers to the T.1 specification had also enabled purchasers to assess these standard designs in service and, where necessary, to propose modifications.

The effect on manufacture had been that production planning had been reorganised to give a shorter time cycle at a lower cost. Each size of transformer was planned for batch production. Components and sub-assemblies common to a number of different ratings of transformers could be grouped together and planned for quantity production for stock, with a consequent reduction in unit cost.

While the contribution of standardisation to the reduction of engineering and manufacturing costs was considerable, it was important that the specifications, once agreed, should be left unaltered for a reasonable period.

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DISTRIBUTION

In a paper "The Post-War Development of the Distribution of Electricity," Mr. G. F. Pierson and Mr. J. Henderson pointed out that as the demand for electricity in Great Britain was doubling itself every ten years, system reinforcement would continue to be an absorbing problem. To deal with this, the method now most generally adopted was to limit the capacity of transformers installed at a given point and to increase the number of points at which power was fed from the next higher voltage. In meeting post-war requirements both mains and transformers had been loaded close to the level at which some reduction in life might be anticipated; and new materials and methods of construction had been exploited to the full.

A number of major developments had taken place in the switchgear field, many of them aiming to get a quart into a pint pot. Examples of this were the 250 MVA 11-kV unit, which was now obtainable in the same frame size as the 150 MVA switch of a few years ago; and the weatherproof cubicle type of out-door 33 kV switchgear, which enabled important switching points to be estalishbed in congested areas.

Three new departures from normal switchgear practice, which were worthy of mention, were the introduction of high-speed auto-reclosers for service on 11 kV overhead lines; the slow melting fuses associated with them; and isolators fitted with interrupter heads. These heads had been developed for use on 11 kV, 33 kV and 66 kV systems and had proved suitable for employment on Area Board networks.

HOW MANY ELECTRIC SOCKETS IN THE HOME?

Many householders will have tried to run a wireless, a fire, and standard lamp from a single socket; will have experienced the discomfort—and possibly recognised the danger—of lengths of flex trailing around the room. They may have wanted a table lamp, or a fan, or a toaster; but decided that the makeshift grid system that was developing should not be added to. Lack of outlet sockets and lighting points in both old and new houses has done much to prevent full advantage being taken of electrical power.

A study of the problem and how it arose has been made by Mr. E. J. Davies. In his paper "The Economics of a Well-wired Home," he pointed out that the expected life-span of houses recently erected was about 50 years. The use of electricity in the home in this period should increase enormously. The author drew up lists of the equipment that might be expected in each room, and concluded that an average three-bedroomed house needed 37 lighting points and 32 socket outlets. As a specific example, here is the equipment that he suggests for the lounge:

General or concealed lighting	Fire
Portable and standard lamp	Vacuum cleaner
Wall lighting	Radiogram
Recess lighting	Television
Television lighting	Clock
Multi-point switch	Fan
	Floor polisher

A present-day lounge is likely to have one socket and one centre light.

The need for plenty of socket outlets has certainly been recognised before now. A post-war study committee was convened by the Institution of Electrical Engineers and in 1944 "Post-war Building Studies Number 11" was published. It contained the following passage: "As a minimum provision, which could meet most requirements, it is recommended that one socket-outlet should be provided in every room wall space exceeding 3 ft. in length, with additional outlets in longer walls placed so that no point along the floor line is more than 6 ft. from an outlet. These socket outlets should be of the proposed standard type. Some thirty to fifty of these socket-outlets would be required in a typical detached self-contained house of the larger type."

But the recommendation was rarely, if ever, carried out. In 1949 the Ministry of Health recommended a very much smaller number of sockets. In 1953 the Ministry of Housing and Local Government published "Quicker Completion of Housing Interiors." In the paragraph that dealt with electrical matters the report said ". . . it is important that the number of light and power points in a house should be kept to a minimum." Mr. Davies's comment was "In this way the carefully considered recommendations of 1944 were arbitrarily set aside by a purely temporal expediency." Later in his paper he went on to remark: "The resulting demand for extra outlets and lighting points, coupled with the comparatively high cost of making additions to existing installations, was a direct encouragement to the amateur wireman —to the serious detriment of wiring standards and public safety. The use of adaptors also increased, with its consequent danger from long trailing flexes, a particularly severe risk as far as fire damage is concerned."

The following figures were quoted to demonstrate the extravagance of inadequate wiring and the high cost of remedying it. The estimates for conversion do not take account of redecoration, making-good walls, and other requirements.

	Equipment for new house	Cost	Comment
A	12 lighting points 6 socket-outlets	£30	Quite usual. Inadequate. Accident prone house.
B	12 lighting points 16 socket-outlets	£50	Average standard.
C	37 lighting points 32 socket-outlets	£80	Excellent lighting. Not accident prone.
Cost of conversions after occupation of the house:			
A to B		£35	
B to C		£60	

SIMULATED-FLIGHT ENGINE-TEST FACILITY AT N.G.T.E.

2—THE ENGINE-TEST PROBLEM

By R. P. Probert, M.A.

Other articles in this series (June 14, page 750 and June 21, page 780) have discussed why full-scale aero-engine test equipment, only recently introduced in the United Kingdom, is now being built up at the National Gas Turbine Establishment; and have described the large power, water and air displacement services being provided to fulfil the need. This article examines the engine-test problem and describes the actual engine-test installations now built or under construction.

All engines now in service are basically for subsonic flight and have been developed without the assistance of full-scale engine test plant. Such equipment would have been used, and now will be used, for the following purposes associated with subsonic flight: (i) performance testing at steady conditions; (ii) functional testing under unsteady conditions; (iii) the study and control of engine icing; (iv) the development of reheat systems; and (v) operating problems such as relighting at altitude. However, it is for supersonic flight that an engine test plant becomes essential rather than desirable.

PROBLEM OF SUPERSONIC FLIGHT

As aircraft become truly supersonic, the engine development problems undergo a drastic change. Sea-level static operation on a test bed is no longer even roughly near the worst stress or temperature cases, and test plant must be provided to simulate the worst flight conditions unless risks are to be accepted in flight of a kind which have not been accepted before. This is the compelling reason for a test plant now, but there are more subtle reasons which may prove equally significant in the long run. A summary of supersonic engine problems is needed to introduce the plant problems.

Fig. 11(*a*) illustrates a supersonic turbojet system. In flight at supersonic speeds the high velocity of the air relative to the engine may be diffused within the intake to give very high pressure ratios from the intake alone. Indeed, at Mach 3 the intake pressure ratio may be 20 to 1 while the engine rotor creates no significant extra pressure aft of the turbine. Unless the turbine temperature is very high, the net rotor effect may be to cause a loss. In any case much of the heat added in the engine cycle may be added in the reheat system. Efficient expansion of the propulsive jet will require a convergent/divergent nozzle with most of the expansion taking place after the throat.

A ram-jet (Fig. 11 (*b*)), has no rotor and must be accelerated by some entirely independent motor to high speeds. In the case of the turbojet, the normal rotor system may be thought of as a means of providing pressure and thrust while accelerating to high speed, and thereafter the system really depends for thrust upon principles analogous to the ramjet. In both cases, once high speed is reached, the thrust and economy achieved depend primarily upon efficient diffusion and expansion and on the temperature of the propulsive jet.

Now to achieve the potential thrust and economy of either engine over the flight speed range, some complicated rules prevail. Each of the main components, intake, rotor system, reheat and propelling nozzle must be suitably matched together in air flow, pressure, etc., so that each is working efficiently. The intake, being in effect a reversed convergent/divergent nozzle, has choking flow limits depending upon flight speed; the engine has a flow consumption determined by rotational speed, flight temperature and back pressure; and the nozzle flow is dependent upon the turbine exhaust pressure and reheat temperature. In the most general case the intake area, the intake throat area, and the nozzle throat and exhaust area must be varied consistently with r.p.m. and temperature limits to maintain aerodynamic and thermodynamic efficiency. The penalty of mismatching may arise in two ways, firstly, as poor performance and secondly as poor performance allied with instability. In the event of excessive back pressure or flow restriction arising on either the intake or rotor, one or both may surge with damaging effects to the engine. In these circumstances, the dynamic problem of the system which controls the components and their matching becomes important too when either flight or engine changes occur, and the matching arrangements chosen must take account of control characteristics. Before getting to these critical factors in design and development it must be recognised that the intake and exhaust system are no longer simple fixed parts, sometimes not considered in the past to be part of the engine at all, but have become working mechanisms with vital operating and control characteristics. The nozzle especially may experience very high working gas temperatures and may be a critical feature of mechanical design.

Not only are there more engine components but the physical working conditions throughout have become more arduous. In supersonic flight, lift-to-drag ratios are much lower than in subsonic flight and this requires much greater installed thrusts, often reflected in bigger engine sizes. Moreover, the need to save fuel by accelerating quickly and climbing at high speed generally requires that acceleration occurs at the lower altitudes where inertia has the least relative effect. One consequence is that engines and aircraft have to operate, at least briefly, at conditions where ram pressures are much higher than in subsonic flight, while the very fact of flying at supersonic speeds implies that ram temperatures go up also. The value of ram pressure reached, or the lower limit of altitude against flight speed, varies with the application. Very large aircraft may achieve pressures of 2 atmospheres while small missiles may achieve 6 or 8 atmospheres. In either case, ram temperatures may increase to 200 deg.-300 deg. C. and may well go higher, limited only by the ability to deal with the cooling problems. These conditions then define the worst mechanical problems of future engines.

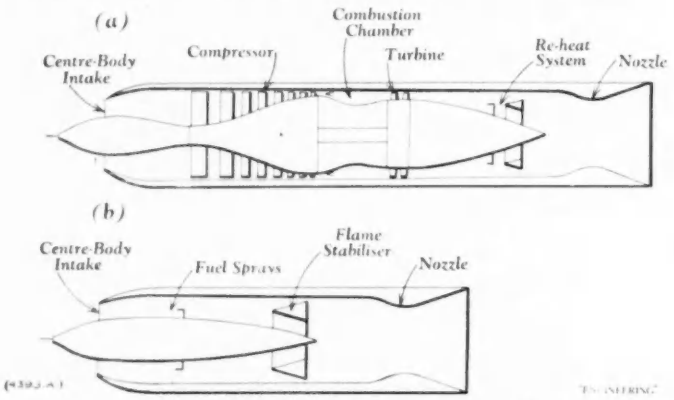


Fig. 11 Engines designed for supersonic flight: (*a*) Supersonic turbojet. (*b*) Ramjet.

ENGINE AIR FLOW DEMAND

The engine types of greatest concern are: (*a*) The gas-turbine-driven propeller; (*b*) the subsonic jet engine; (*c*) the supersonic jet engine which necessarily has some duties in subsonic flight, though more restricted than current types under (*b*), and (*d*) ramjet engines for missiles and very high-speed aircraft. There are other engines of mixed parentage and doubtful application whose demands fall within those of the types listed above.

The air flow consumed by a turbine engine at constant r.p.m. increases in proportion to the ram pressure of air supplied to it, but falls off from this with increase of ram temperature. Unfortunately, as stated earlier, the increase in flight speed and ram pressure is accompanied in practice by bigger unit engine sizes. In terms of plant power to supply the required test conditions at full stress there is, therefore, a very sharp increase indeed. Table I presents some representative figures.

TABLE I.—*Plant Air Supply and Power Requirements at Sea Level*

	Propeller turbines	Current turbojets	Supersonic turbojets
Flow, lb. per sec. ..	50	200	600
Pressure, atm. ..	1·2	1·5	3·0
Plant, h.p.	700	5,500	50,000

This table does not tell the whole story. Partly for reasons of efficiency, and partly to limit stresses, the cruising height of supersonic machines increases with speed. Now although this has the effect of keeping the cruising-air mass-flow rates within those listed above for sea-level conditions, the volume flow of air inspired continues to increase indefinitely with flight speed. After Mach 1 the volume flow does, in fact, increase in rough proportion to flight speed. Thus when we consider the plant capacity needed to pump away the exhaust at top altitude conditions from engines on representative tests we get the picture illustrated by Table II.

In considering ground test plant for engines it is at once obvious that the supersonic engines set the extreme demands for mass flow and power, recompression pressure ratio and displacement capacity of machinery exhausting back to atmosphere.

The only respect in which the lower flight-

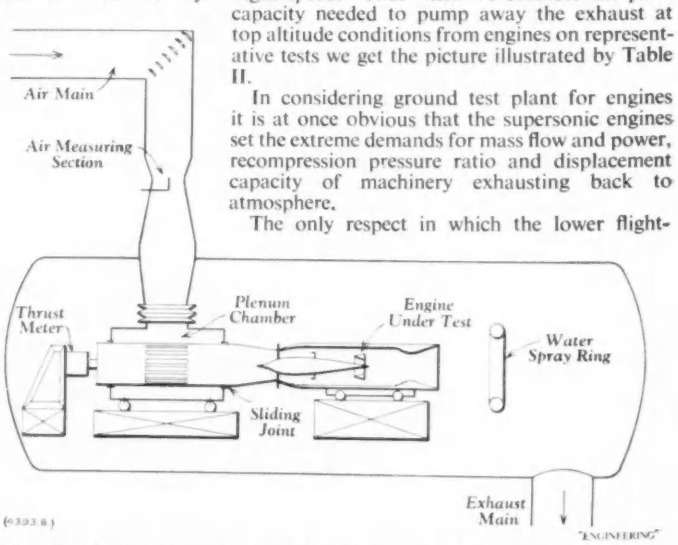


Fig. 12 Connected test rig; air is piped subsonically to the engine at the pressure and temperature reached after intake diffusion in flight.

TABLE II.—*Plant Capacity Required at Maximum Altitude*

	Propeller turbines	Current turbojets	Supersonic turbojets
Cruising height, ft.	30,000	50,000	70,000
Cruising speed, m.p.h	400	600	1,500
Exhaust volume flow after cooling, cub. ft. per sec.	900	7,000	28,000

speed engines set the limiting demand is in the low ram temperature achieved at high altitude. To meet this case an engine air-supply temperature of about 200 deg. K. is needed.

PLANT CAPACITY AND ECONOMISING TECHNIQUES

In tests where the stress and temperature of critical parts are the real concern it is only necessary to ensure that the air conditions within the rotor are properly simulated. Even though the physical conditions are representative of supersonic flight, air will be piped subsonically to the engine at the pressure and temperature reached after intake diffusion in flight. Provided that the engine exhaust-nozzle throat pressure is kept correct, all dependent conditions in the rotor will be properly simulated. Such a test is called a connected test and is illustrated in Fig. 12. If supersonic expansion of the engine nozzle is not itself a critical objective, the exhaust pressure need not be maintained any lower than the minimum engine-throat pressure at the altitude of the test. If the pressure at the engine-compressor inlet is below atmosphere, the correct pressure can be obtained by throttling air supplied either from plant compressors or directly from atmosphere.

PRESSURE RECOVERY

When the engine-exhaust nozzle is itself a critical item of test, then the full exhaust expansion must be carried out right down to the true altitude pressure with a large increase in the exhaust volume flow. The test-plant exhaust capacity to pump this can be reduced by practising a suitable form of diffusion or pressure recovery in the free engine-exhaust jet after discharge. The best system for this purpose is illustrated in Fig. 13, which also shows typical diffuser performance. Here, the free exhaust jet is blown first into a parallel exhaust duct of greater bore than the engine exhaust diameter and then into a tapered diffuser. The system is basically an ejector with zero induced flow and the pressure recovery obtained depends both upon the ratio of diffuser to engine-throat area and upon the engine-exhaust pressure ratio. Large increases in exhaust pressure, to three to six times the altitude pressure, can be obtained in this way with highly supersonic jets, but factors referred to later intervene to limit the chosen recovery values.

When it is the intake/engine matching and functional behaviour at supersonic conditions which are under test, there is no need to expand the engine exhaust beyond the throat pressure and this immediately saves exhaust capacity, but air at correct supersonic speed must be blown at the engine intake from a suitable supersonic nozzle. Now more air must be blown at the engine than it will, in fact, inspire—that is, the area of the jet impinging on the intake must be larger than the engine intake so that disturbances caused by the intake itself will not reflect from the jet boundaries back into the intake and so give unrepresentative engine flow. Frequently many times the engine flow would be desirable for this purpose. When the test takes place at altitude conditions, all this excess of "spill" air must be pumped away by exhaust machinery and this sets a new and altogether greater demand for volume flow than does the extreme engine-exhaust case. It is essential to find efficient methods of pressure recovery or reducing volume flow in the spill air, and the practice of this art is called "spill diffusion."

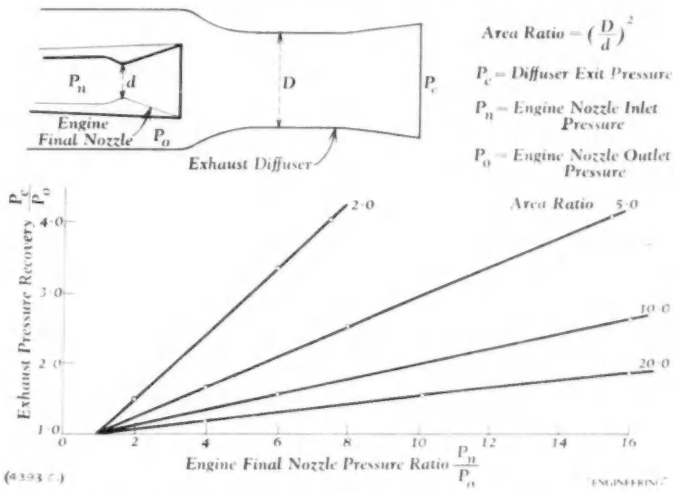


Fig. 13 Typical characteristics of an exhaust jet diffuser.

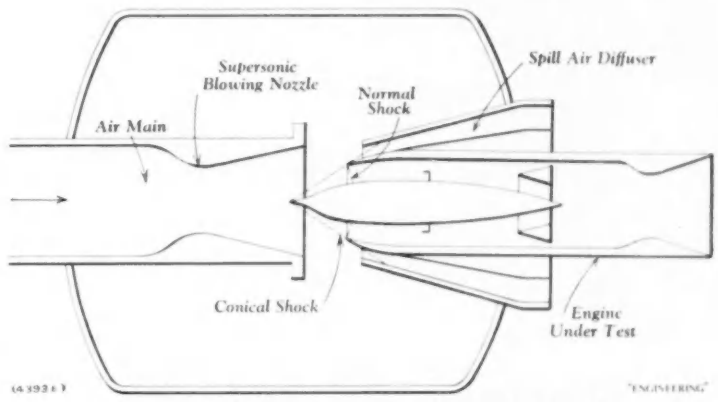


Fig. 14 Free-jet test arrangement without spill diffusion.

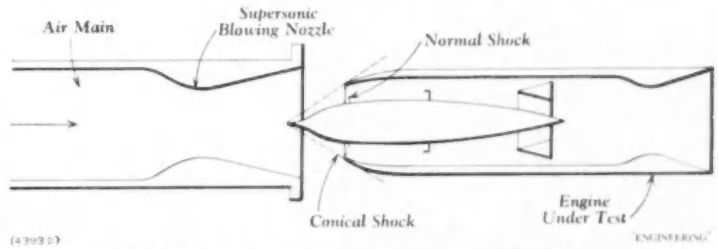


Fig. 15 Free-jet test arrangement with spill diffusion.

FREE-JET TESTING

Supersonic testing of engines is done with "free" supersonic jets, i.e., jets blown into a free space at the jet-exhaust pressure, and the process has come to be known as "free-jet testing." Fig. 14 illustrates a free-jet test without spill diffusion. Air is supplied at the ideal ram pressure and temperature corresponding to some speed and height, and blown through a supersonic nozzle at the engine intake. The pressure and temperature in the jet are then the true altitude conditions. The excess spill air going past the engine later mixes with engine air at the true atmospheric pressure and is then pumped back to atmosphere. With spill diffusion (Fig. 15) the spill air passes into an annular channel defined by two conical shrouds mounted around the engine in which the energy is recovered and the pressure rises above the true altitude pressure. If the spill-diffuser discharge pressure is quite different from the engine-exhaust throat pressure, it will save exhauster volume to pump the two flows separately when the spill flow is several times the engine flow.

The practice of efficient spill diffusion presents some difficult technical and engineering problems. In supersonic flow systems operating at low overall pressure ratios by the aid of diffusion, the applied pressure ratio required to start the system is often higher than that required to maintain it; the difference may be negligible at Mach 1·3 to 1·5 and fairly large at Mach 3. The operation of the engine itself also affects the efficiency of the diffuser. When the engine is at incidence, or when, for some reason, the engine does not absorb its full air flow, large air disturbances are created which change the quantity and pattern of flow into the diffuser and hence its efficiency. Moreover, the efficiency under undisturbed conditions and the effect of given disturbances both depend upon the ratio of spill to engine flow. Another complication is that, for efficient diffusion, both the diffuser inlet area and throat area vary with both the Mach number and the extent of any engine disturbance. Not only diffuser efficiency is of concern. The pressure around the free jet should be maintained at the true altitude pressure whatever the engine and diffuser flow, otherwise pressure-adjusting shocks will be set up within the jet which will affect the engine flow. The free-jet pressure can be maintained by further adjustments to diffuser intake and throat area with some loss in efficiency, but these can be largely avoided by pumping out the chamber around the free-jet and delivering this "by-pass" air back to the main stream at the diffuser exit. The most efficient system of spill diffusion, therefore, is one which is infinitely variable in flight speed above some low starting supersonic speed, with the largest practicable spill ratio and moving diffuser walls which permit variation in inlet and throat area and with a by-pass compressor extracting the small air quantity not passing into the diffuser. The requirement for adjustment of supersonic nozzle and diffuser shapes practically dictates rectangular flow sections.

For small engines where sufficient plant volume-flow and pressure-ratio exist, and if no large disturbances are expected in the diffuser flow, much simpler arrangements can be effective. If the air is then supplied through a fixed geometry (one Mach number of discharge) axially symmetric nozzle and the diffuser is also of circular symmetry, then forward axial movement of the outer shroud opens up the flow areas for starting and efficient operation may be achieved at one Mach number over a narrow range of engine conditions. This system too benefits considerably from by-pass evacuation of the space around the free-jet.

It is, in fact, only practicable to test engines economically by the use of these specialised

techniques. Without using them to reduce the volume flow, the scale and cost of equipment needed for testing supersonic engines would be prohibitive.

The systems described can be made to work over a wide range of engine conditions with only two or three times the engine flow supplied by the free-jet, but in this case the flow around the engine nacelle is not correctly simulated, only flow into the engine is correct. Very large installations employing perhaps one hundred times the engine flow could be built at proportionately greater cost. These would be complete supersonic engine wind tunnels having simpler diffusion problems. However, the scale becomes so very large that rapid changes of flight speed or incidence are not possible, and it is questionable whether any extra test data could be obtained in any important respects, while less seems possible in some. Certainly, the increase in utility would be but a fraction of the extra cost.

VERSATILITY OF THE AIR COMPRESSION SYSTEM

When consideration of air services and test arrangements began, it was quite impossible to say what the final air demands would prove to be. Considerable research was needed to establish supersonic test techniques and their efficiency. For the same reasons, the groupings of different tests within one installation could not be predicted accurately, that is, the air distribution needs were not defined. It was therefore necessary to adopt a scheme flexible in air compression and evacuation duty and a flexible air distribution scheme. The air-pumping plant consists of eight sets of three machines which can run as compressors or exhausters in 3 to 1 or 9 to 1 staging. Each set has individual pressure and exhaust mains all going to the main test site. A cross-over main feeds the output of seven sets into the eighth set which permits site evacuation of 1/27 or 1/81 of an atmosphere. Variable degrees of inter-cooling and aftercooling can be used to vary the delivery temperature and, to a lesser degree, the pressure ratio of the sets. This system has proved to be very adaptable indeed. Arrangements of blow and suck varying in quantity and degree can be chosen freely at any place for any purpose without compromising other needs at different times and places, and it has proved possible to plan subsequently with convenience all tests and emplacements as their duty is fully defined.

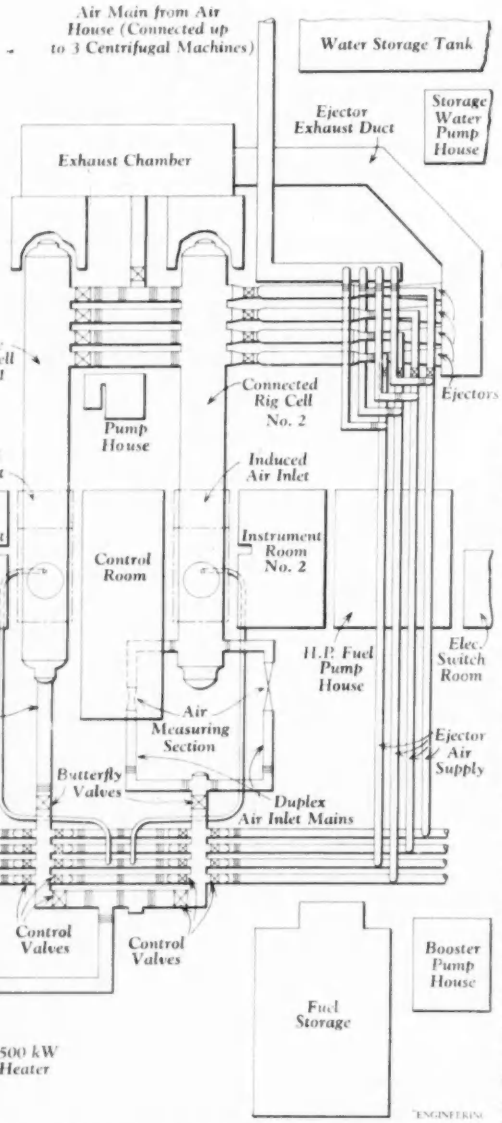


Fig. 16 The first two test cells for ramjet testing on an existing air supply.

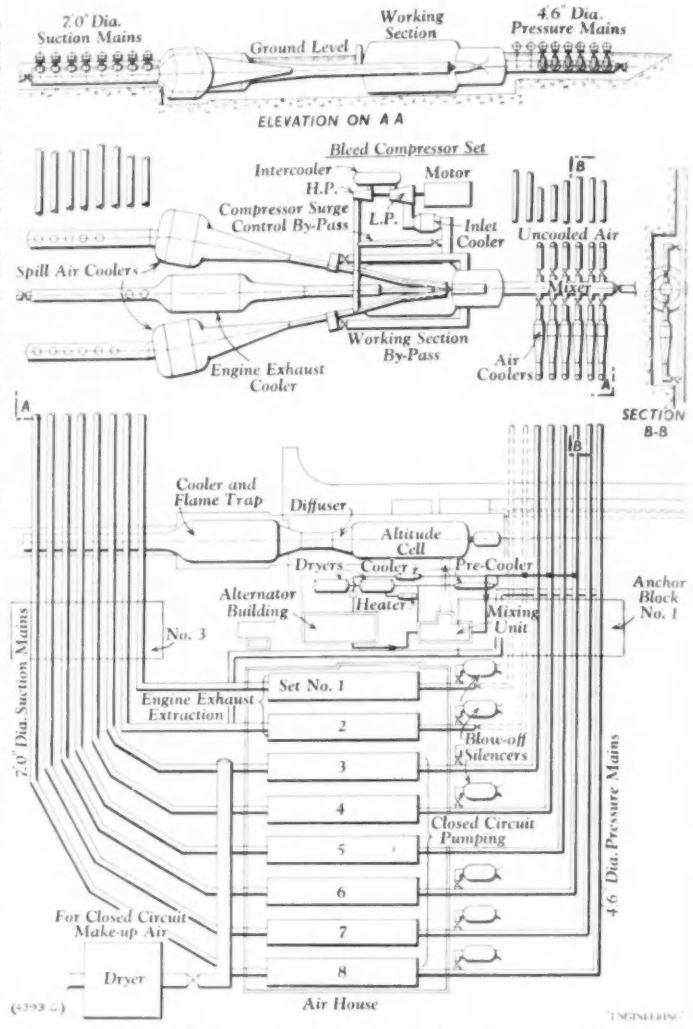


Fig. 17 Layout of the altitude cell, which is designed for connected testing at altitude exhaust conditions, at any inlet temperature, and with ram air at or below atmospheric pressure.

FIRST TWO CELLS

The first two cells were initially designed for ramjet testing on an existing air supply of 200 lb. per sec. at 6 atmospheres pressure. The general layout is shown in Fig. 16.

The air compressors were not used as exhausters mainly because of inherent operating requirements and also to avoid the high cost of suction air mains. Suction is provided by ejectors operating on the high-pressure air supply, a system which is cheap in first cost though higher in running cost, but this was not critical since ramjets do not operate for long periods. Considerable research has gone into the design of air ejectors, and the displacement capacity of the ejectors is about equal to the displacement of the air compressors driving them. It is one overwhelming advantage of air ejectors in this context that far lower operating pressures (or higher altitudes) can be reached by using 6-to-1 air to drive an ejector than by using the corresponding compressors as exhausters.

Two test cells 12 ft. in diameter and about 120 ft. long lie one on each side of a control room which offers a direct view of engines on test. One cell is for "free-jet" and the other for "connected" testing. The air supply to the latter is measured for test purposes in the limbs of the bifurcated supply ducts provided. High-pressure air may be fed to either cell, or diverted to drive the ejectors which evacuate the cells at low pressure. The "connected" cell is evacuated directly by the ejectors, but the free-jet cell is evacuated through the exhaust end of the connected cell by transfer ducts. Alternatively, each cell can be opened to discharge essentially at atmospheric pressure into a silencing stack to which ejector exhausts are also returned.

Above atmospheric pressure the temperature of the air supply can be regulated with compressor aftercoolers between about 50 deg. and 250 deg. C. Below atmospheric pressure, the temperature can also be regulated by bleeding in atmospheric air to mix with throttled compressor air. In either case two 1,500 kW heaters can be used for trimming the air temperature and as a temperature boost. Each cell may therefore take in air at high or low pressure at high or low temperature and exhaust to atmo-

sphere or altitude conditions. While exhausting to atmosphere, 8 ft. diameter cell vents can be opened upstream of the engine to permit induction of atmospheric air for exhaust gas cooling, but at any operating condition water is injected into the exhaust to keep the final temperature to 100 deg. C. or below. The air-supply pressure to each cell is finally controlled by fast-operating butterfly valves. They can be operated together so that flow is diverted quickly from one cell to the other with controlled rate of change and with no change in main supply pressure.

Within the connected cell, air passes to the engine through a floating thrust box, really a plenum chamber from which air passes radially into the engine supply duct. This duct passes through both ends of the box and can float axially within the limits of annular diaphragm seals at each end. The float is restrained by hydraulic thrust-measuring gear. Within the free-jet cell, air is blown at the engine through fixed-geometry supersonic nozzles mounted in a yawing machine. This is an articulated duct system composed of telescopic pipes and ball joints. It moves within a frame under the control of hydraulic jacks and provides a wide range of engine incidence. A forged ring on the cell wall downstream of the yaw machine carries a bulkhead and spill diffuser gear.

The site has local water and fuel storage of 300,000 and 40,000 gallons respectively and a pumping capacity of 1,700 and 250 gallons per minute respectively. Each cell drains unevaporated water into a barometric well at a controlled level with an extraction system matching the fuel input to prevent flooding on an engine cut. A separate circuit provides various engine and test-cell cooling-water supplies.

The free-jet cell is equipped with a short-duration spark-discharge system for photographing shock-wave phenomena at the engine intake and each cell is matched by one instrument room for the remote photographic recording of all test results.

With the advent of the new larger air supply for turbine-engine trials, it has been possible to expand the duty of the first two cells by importing air from up to three of the new machines. This new supply at higher pressure improves the ejector exhaust capacity in both cells and can be used directly in the high-pressure supply of both cells. With these supplies the free-jet cell can test ramjet engines supersonically at Mach numbers up to 3 and higher without exact altitude exhaust pressure. Processed air enters the plenum chamber from an external ring main through a series of short connecting ducts and ports. In use for propeller turbine tests, the engine will be connected by shafting through the front of the shell to external dynamometers for power absorption. It will draw air directly from the plenum chamber while its exhaust will be ducted first through a sealed joint in the bulkhead and then right through the turbojet chamber to the outlet diffuser. A turbojet on test will be fed from the plenum chamber through a pipe sealed into the bulkhead and will also exhaust into the diffuser. Around the outer edge of the bulkhead is a ring of ports each leading to a valve through short ducting. These valves will bypass air around the engine from the plenum chamber to the exhaust system; they can be used to maintain constant plant airflow and constant pressures in the plant system when engine air-consumption changes rapidly during acceleration or deceleration of the engine. A regulated airbleed into the exhaust system from atmosphere is provided after the cooler and before the main valves into the exhaust mains. Its main purposes are to assist in maintaining constant exhaust line pressure and plant load when engine transients

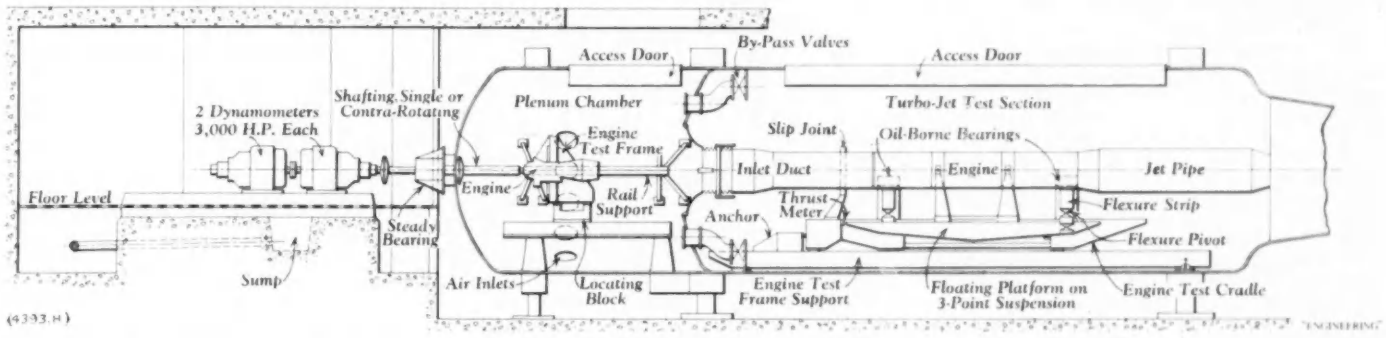


Fig. 18 Section through altitude cell.

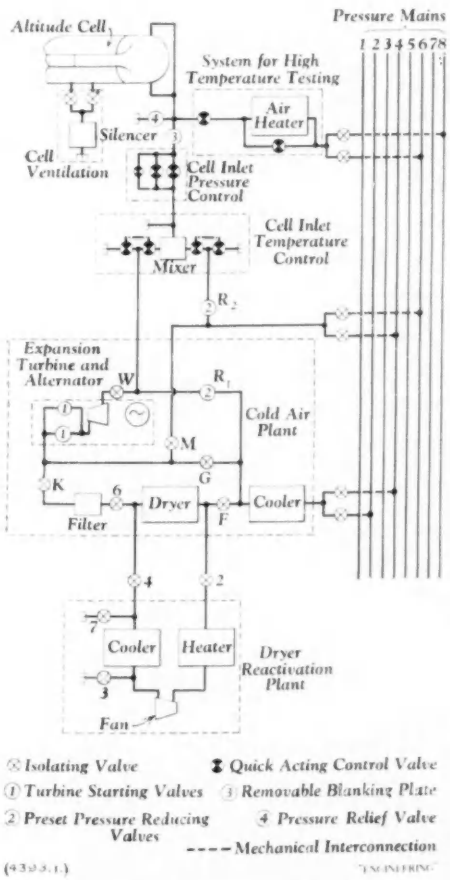


Fig. 19 Air-processing circuit.

temperature simulation at heights up to 70,000 ft., while the connected cell will test ramjets and turbojets up to their maximum density test conditions. It will also provide a wide range of ramjet combustion-system testing and a useful range of reheat trials on turbojet engines. The greater part of turbine-engine testing cannot be accomplished in these two cells, which were first planned for less arduous objectives. The outstanding duties will therefore fall to two other cells which are described successively.

THIRD OR ALTITUDE CELL

The duty of the altitude cell is to do connected testing on any engine at altitude exhaust conditions, at any inlet temperature, but with the ram-air supply normally at atmospheric pressure or below. The cell is not primarily intended for high density or supersonic inlet testing.

The layout of the cell and associated services is shown in Fig. 17. The cell itself is a steel shell 20 ft. in diameter and 80 ft. long. It lies in a deep cutting at right angles to the supply and exhaust mains, to which it exhausts through a diffuser and cooling system. The cutting walls and superstructure building contain a variety of the smaller services. The larger services lie outside the cutting; the cold-air plant occupies a site between the main compressor-plant hall and the cell, while an air heater will stand on the other side of the supply mains from the cell. A central control and instrumentation building also stands beyond the pressure mains where it can serve both the new test cells and in certain respects the ramjet cells also.

The test cell (Fig. 18) is divided into two compartments by a bulkhead about 20 ft. along the cell. Each compartment has a 14 ft. wide removable cover or hatch for loading engines and gear into the cell. The upstream compartment serves both as the site for propeller-turbine engines on test and also as a plenum chamber in which supply air is maintained at the desired ram conditions of simulated flight. The downstream chamber is the site of turbojet engines on test and in operation is maintained at the occur, and also to provide sensitive exhaust-pressure regulation when the plant is near its limiting exhauster performance.

The turbojet chamber will contain a floating platform, adjustable in axial position along the cell, and engine-thrust measurements will be taken from it. Engines can then be loaded outside the cell on to individual mounting dollies and the whole assembly loaded on to the floating platform. The engine air-supply ducting must contain a slip joint to permit expansion and accurate thrust measurement.

SUPPLY AIR-PROCESSING SYSTEM

An engine may require cold or hot air according to simulated flight speed and height, and air temperature should be set quickly and maintained despite rapid change of engine air consumption. In some cases it may be required to programme fairly rapid changes of air temperature, pressure, and flow to simulate transient flight conditions. The system of air-processing and regulation has been chosen to give simple fast controls avoiding as many interactions as possible. Fig. 19 illustrates the circuit.

The compressor plant will supply air at temperatures of compression up to 250 deg. C. The main control system, and the account of it immediately below, are concerned only with temperatures up to this limit.

Air at 200 lb. per sec. and 9 atmospheres may be delivered from one compressor to the cold air plant, either hot at 250 deg. C. or aftercooled to 60 deg. C. Here, not less than 100 lb. per sec. is cooled to about 30 deg. C., condensed water is extracted, and air is finally dried in beds of desiccant at high pressure. Dry air at 100 lb. per sec. is then expanded through a turbine at constant back pressure to a fixed temperature of −75 deg. C. The balance of the supply by-passes the turbine and is therefore delivered either dry at 30 deg. C., or humid at 250 deg. C., and is throttled down to the same pressure as the turbine exhaust. Both lines feed constant flows at equal pressure of about 4 lb. per sq. in. and at constant temperatures to a mixing system.

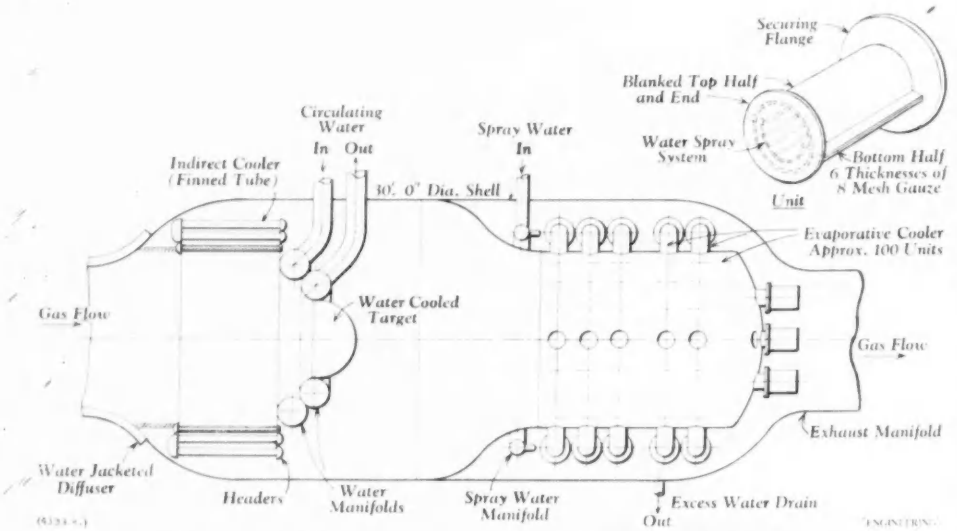


Fig. 20 Cooler and flame trap.

Air from each line may be fed either into the mixer or blown off to atmosphere. On each constant-temperature supply line, the valves in the blow-off and mixer ports are mechanically linked to maintain constant effective area, and this system therefore maintains the constant back-pressure in the turbine. Pressure after the mixer in the delivery line is essentially atmospheric and is maintained by means of a free atmospheric vent in the delivery line to the cell. The mixed airflow is always greater than the engine demand so the excess blows off gently to atmosphere. The mixing system can be used with air supplies of any two different temperatures, and by adjusting the valves, up to a maximum flow of 400 lb. per sec. (two compressors) can be used. With this system, then, air is delivered always at constant pressure to the cell with rapid control of temperatures in a series of temperature ranges, e.g., — 75 deg. C. to 30 deg. C., or 60 deg. C. to 250 deg. C. All supply lines will be internally lagged to reduce heat capacity effects.

Flow and pressures in the cell will be controlled in the following way. Enough exhausters are put on line to meet the maximum volume flow and minimum pressure demand. Ram pressure and exhaust pressure are then adjusted by setting the main inlet throttle to the cell ring main, and the exhaust throttles or airbleed. This is done with the engine by-pass open. As the engine starts or changes speed, the by-pass valves are regulated by servos to maintain ram conditions in the plenum chamber, and the inbleed is regulated to maintain engine exhaust pressure. Alternatively, if the engine is at full r.p.m. and it is desired to simulate a flight speed change, then the inlet throttle can be programmed to change the plenum chamber pressure while the by-pass valves or the inbleed regulate a constant downstream cell pressure. In this way the controls of flow pressure and temperature are separated and simplified.

When very high air temperatures are demanded, the normal temperature-process system is by-passed and compressed air is fed directly from the heater to the cell. Again, a heater by-pass will be used to regulate the mixed temperature after the heater.

DIFFUSER AND COOLING SYSTEM

The exhauster volume-flow of this plant is about one half of that required to exhaust at true altitude pressure a large engine at high supersonic speed; an exhaust diffuser is therefore quite essential and must deliver about 2-to-1 pressure ratio in the worst case. The ejector-type diffuser to be provided has a parallel water-cooled throat of such an area that it will give about this pressure ratio in the extreme test case. Now the conditions of such a test can be set up relatively slowly without embarrassment to the plant as a whole. The particular diffuser arrangement chosen is one which also gives only a small increase in exhaust line pressure when a large engine is rapidly accelerated in r.p.m. at subsonic flight conditions, and this can be cancelled by the inbleed without a sharp load change on the exhausters. Unless the diffuser could be matched in both these senses it would lead to awkward plant-control problems. In effect it is used as a diffuser only when the maximum engine volume-flow demand occurs.

Hot gas leaves the diffuser through a divergent section and passes into the cooler. The cooler elements are longitudinal water-tube bundles arranged in an annular pattern so that the gas flows radially outwards. At the downstream end of the tubes, the central passage is blocked by a target plate and water headers. This cooler only brings the gas temperature down to 150 deg. C. in the full-load cases. The final temperature drop to 50 deg. C. (maximum exhauster inlet) or less is achieved directly by water in an evaporative cooling system, for reasons of plant safety and economy.

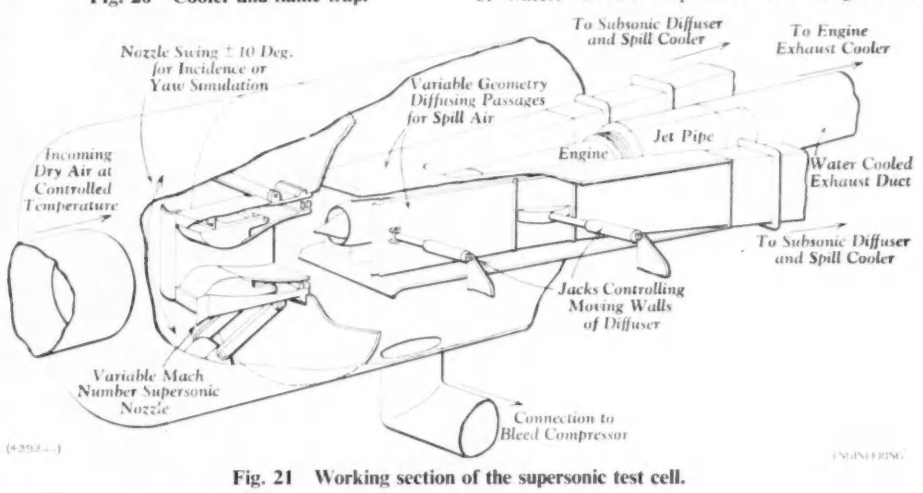

Nozzle Swing ± 10 Deg. for Incidence or Yaw Simulation
To Subsonic Diffuser and Spill Cooler
To Engine Exhaust Cooler
Variable Geometry Diffusing Passages for Spill Air
Jet Pipe
Engine
Incoming Dry Air at Controlled Temperature
Water Cooled Exhaust Duct
To Subsonic Diffuser and Spill Cooler
Jacks Controlling Moving Walls of Diffuser
Variable Mach Number Supersonic Nozzle
Connection to Bleed Compressor

Fig. 21 Working section of the supersonic test cell.

EXPLOSION PRECAUTIONS

In any fully enclosed combustion system there is a risk of fire and explosion. The risk is obvious here because fuel lines may break or the engine may cut while the engine exhaust itself is an unavoidable ignition source. Considerable effort has been given to these problems. Apart from the obvious precautions of preventing unnecessary fuel entering and avoiding stray ignition sources a first measure is to ensure that if an explosion should occur then the result should not be catastrophic. This is done partly by designing the main steel chambers to withstand the full explosion pressure, but this does not prevent an explosion communicating with the main exhauster plant. Explosion relief ports have been investigated, but the rates of pressure rise in the highly turbulent conditions existing here are so fast that practicable rates of valve opening do not lead to great relief. Water injected as a spray downstream of the engine to drench a combustion wave passing into the exhaust system and so limit the volume within which explosion occurs is found to be erratic and unreliable. On the other hand, various kinds of water-cooled flame-trap have given reliable results in rig trials. The preferred form consists of layers of wire gauze wrapped into a cylinder, with radial gas flow, and sprayed with water. This arrangement will act both as a gas cooler and a flame trap. The system chosen in this case (Fig. 20) consists of a bulkhead across the cooler shell behind the indirect cooler, bearing multiple packs of water-sprayed gauze.

It would be possible to use water alone to cool the exhaust gases, but unless very large water reservoirs are available so that the sensible heat of water, rather than the latent heat of steam, is used as the heat sink, the system is uneconomical in exhauster capacity. At a given mixture temperature the water-vapour fraction in equilibrium with air increases at low pressure due to the fall in boiling temperature of water. In an evaporative cooler, gases at high temperature will have sufficient heat to raise a large fraction of steam, but if they are first cooled indirectly the steam fraction and temperature at equilibrium fall with the degree of indirect cooling employed. The present system uses the flame trap to cool by evaporating from 150 deg. C. and thereby gives a big reduction in the size and cost of the indirect cooler for only a small loss in exhauster-air capacity.

Another safety measure will also be employed. Torches have been developed to ignite flowing mixtures over a wide range of mixture strength and flow velocity. These will be installed at the exit of the diffuser. When, therefore, a stream of unburned mixture, due say to an engine cut, blows into the cooler and exhaust system, it is burned off at this point and the system fills with inert products instead of explodible gas. An engine relight will not then lead to explosion. In the unusual case of a mixture richer than about 8 to 1 air/fuel ratio developing, the torches will be unable to ignite the mixture as it flows past. As the flowing mixture weakens, the torch might itself set off explosive burning. It is not, therefore, a complete substitute for a flame trap, but it should of itself inhibit the most frequent circumstances of explosion.

Although not primarily intended for high-density testing, it is in fact possible to feed air at pressures up to about 2½ atmospheres into the altitude cell. Because of the very wide range of air temperature to be employed and its effects both upon expansion and metal properties, the cell and bulkhead are lagged internally. The cell is supported at points at the ends of horizontal diameters. It is anchored at the front, and expands rearwards by an expansion joint which limits the deflection of the exhaust mains. Preliminary engine check-running may be done without starting up the main plant by opening

up an atmospheric blow-off at the end of the exhaust manifold. The plenum chamber cannot be used with the hottest air, which must be piped from the inlet ports through the plenum chamber directly to the engine. During icing tests the plenum chamber can be sprayed with water to create normal atmospheric humidity, while icing sprays will be injected directly into the engine supply duct.

FOURTH OR SUPERSONIC CELL

The purpose of the fourth cell is to run engines with intakes in supersonic air streams of varying speed and density with the greatest possible freedom and safety in engine handling, incidence, rate of change of flight speed, etc. Detailed manufacturing design of the installation has begun, following design studies of the project as a whole and critical items within it. The size and duty of a complex installation of this kind depend upon the efficiency of the test techniques and the resources available. Unless the combined effect of the two main factors is such as to yield a certain critical test capacity, the system might not be worth building at all on the scale they define. The present system is expected to perform extensive, but not exhaustive, tests on the larger sizes of supersonic turbojet over the speed range in which they are expected to be the main propulsion plant of aircraft. Smaller engines can be tested over a little wider range. Had the available skills and resources yielded some 20 per cent. or so less in result it would not have been possible to test actual service engines in development, and a small installation to test model engines of functional size for research purposes would then have been the only really useful level of test capacity. A great effort has been made to find techniques yielding this critical level of utility below which a large system would really be a white elephant.

The layout and air circuit of the system are illustrated in Fig. 17. Six compressor sets with all units in parallel operate in a form of closed circuit. They supply air to a variable Mach number nozzle which directs an air jet at the engine intake. Air absorbed by the engine is kept separate after discharge from the engine, and after cooling is exhausted by the remaining two compressor sets. All the spill air is diffused in two ducts built around the engine, then cooled in two "spill coolers." Enough atmospheric air is sucked in at the compressor inlets to make up the air lost by engine consumption and the whole circuit flow is then pumped back to the nozzle. This is the basic system.

The spill coolers have always to reduce the compressor inlet temperature to the lowest possible value, while the main control of air temperature in the free jet is by selective use of compressor aftercoolers. Higher free-jet temperatures can be obtained by putting some air through the indirect heater associated with the third cell. To prevent condensation shocks in the free jet, the air in the circuit must be dry. The make-up air to the compressor is therefore dried before entry.

The closed circuit has the great advantage that the pressure level (or effective altitude) can be changed without change in the pressure ratio and volume flow of the main compressors. The pressure is controlled by those compressors exhausting the engine. This arrangement will always yield the largest free-jet area the compressors can operate, and for a given engine this beneficial effect leads to marked improvement in aerodynamic efficiency of the spill diffusers with very important secondary gains in the designed free-jet area. The closed circuit also minimises the cost of air-drying equipment. In other ways the closed circuit is less favourable. Notably the limit of single-stage pressure ratio, when taken with diffuser efficiency factors, limits the top test Mach number. For a large engine the top speed will be about Mach 2·5, but small engines may be tested at speeds approaching Mach 3·0. Fig. 21 illustrates the engine test gear in more detail.

The free-jet nozzle will consist of two fixed walls and two adjustable ones. The discharge area is constant with speed, and the speed at outlet is set by swinging throat blocks into positions giving appropriate required throat areas. Steel plates attached to the throat blocks and the outlet then bend into shapes which give uniform outlet-flow distribution in the free jet. The spill diffusers also have parallel top and bottom surfaces so that the external wall of each diffuser may be jacked to give variable intake and throat area in each diffuser. Flight incidence conditions are created by swinging the whole nozzle. The free-jet nozzle is mounted within a pressure vessel which serves as a plenum chamber from which it draws air. The engine and diffusers are housed within a vessel at the true altitude pressure. A by-pass compressor, taking about 4 per cent. of the nozzle flow, evacuates this chamber and delivers the by-pass flow back into the diffuser outlet mains.

The maximum volume flow acceptance of the nozzle occurs at low supersonic speeds when the nozzle throat is open, and the overall pressure ratio is least. This means that the compressors are operating at a low point on their characteristic and also near their maximum volume-flow capacity. Starting at these conditions then defines the largest free-jet section area the compressors can supply. At higher Mach numbers, as the nozzle throat is closed, the volume flow required by the nozzle falls and the pressure ratio rises. The compressors must then operate at progressively higher points on their characteristic and do indeed deliver less volume flow. In general, depending upon the circumstances of the test, they deliver more air than the nozzle requires. Typical values are given in Fig. 22. The excess of air must by-pass both the nozzle and diffuser and is therefore blown back into the diffuser outlets. When small engines are considered and the diffuser efficiency is at its highest, the excess air is sufficient to produce a significant injector effect on the diffuser discharge air. It will therefore be blown axially at high speed into the diffuser ducts at a section of appropriate area, so reducing the overall pressure ratio across the nozzle and the diffuser. It is the improvement of diffuser efficiency allied with the injector effect which permits higher Mach numbers to be reached with small engines.

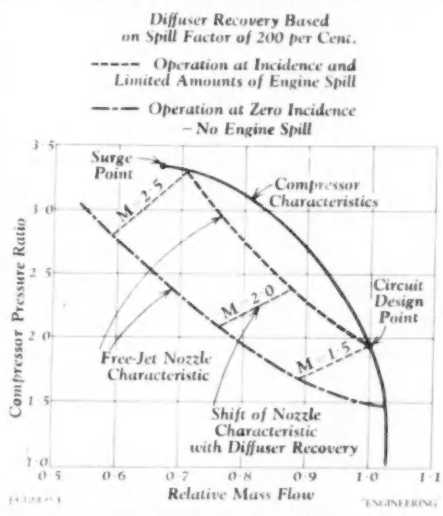


Fig. 22 Matching of free-jet nozzle system with compressor characteristic.

Primary control of flight speed, and of main and by-pass compressor operation, rests entirely with the nozzle throat-area setting, but the nozzle by-pass must adjust automatically to dispose of excess compressor flow, and the diffuser walls must adjust automatically to maintain the altitude pressure in the free-jet plenum chamber. Should an inadvertent setting of excessively high Mach number occur, or some considerable engine disturbance lead to poor diffuser performance, the pressure ratio demanded might exceed the compressor capability and the sets would surge. In this case the nozzle by-pass can be opened to relieve the compressors, but flow conditions to the engine will break down. It is the prime object of the control system to prevent this situation arising.

The arrangement of engine and spill diffusers illustrated is only one of many possibilities. Space is provided to substitute radically different installations should the future require it.

TELEVISION AND AUTOMATIC DATA-PROCESSING

The scale of the newer installations being built is so large that vital control and observation points are necessarily remote from any one central control point. Accordingly, the control station has been taken right out of the actual test installations to a situation where cheap space can be provided for a complete central control and instrument service to each new cell. Observation will therefore be provided by industrial television cameras; the altitude cell, for example, has a series of lighting and observation ports along its length and cameras can be sited where required. An engine assembly bay is provided nearby with separate space for individual manufacturers. Here engines can be built up, equipped with instruments and remote control units and mounted on tailored test frames. Ready access and handling is provided right into each cell. Within the test cell, controls, instruments, etc., will be connected into central services permanently available at the cells.

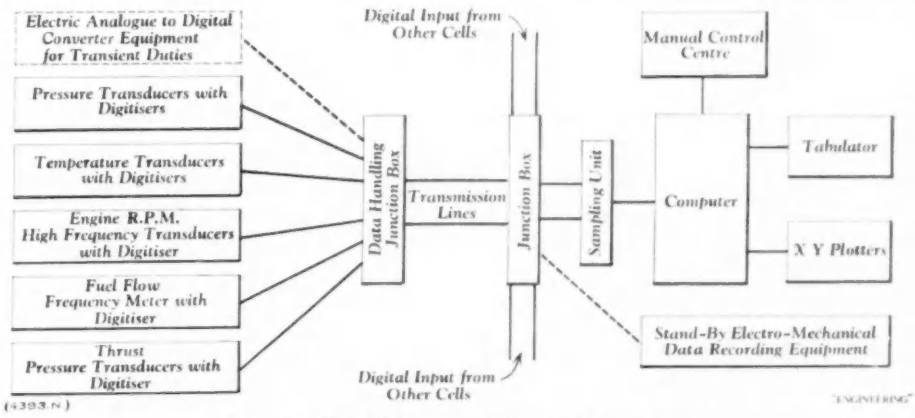


Fig. 23 Block diagram of instrumentation system.

The instrumentation service presents complex and novel problems. Plant operation is expensive and actual running time must be used as efficiently as possible. But equally the plant will provide a unique and vital service, and when required must be capable of rapid turn-round of engines, rapid change from one test to another, and rapid execution of any one test. Among all these needs the requirement is common for rapid accumulation, expression and interpretation of accurate test data. Without a service

of this sort delays would occur in the conduct of tests and of planning successive tests. For all these reasons a comprehensive service of automatic recording, computing and presentation of test results is being set up. A block diagram of the scheme is given in Fig. 23.

All physical outputs from engine instruments, e.g., voltage, pressure, are wired or piped into a relay room adjacent to each cell. Here the signals are converted into digits on a binary decimal scale up to 2^{10}. This information is transferred in code to the control room, sampled through a switching system and stored in memory devices. Ultimately, all data is analysed by an electronic digital computer, and the results stored or plotted graphically by automatic methods as required. Some data, however, can be selected, computed and plotted automatically for the test controller as testing proceeds. This will enable the person in control to call off fruitless tests, or investigate further at once any observed peculiarities and generally to exercise judgment over the progress of tests.

The system as a whole uses recognised methods and available commercial equipment, but specialised transducer techniques to suit the particular needs of the plant are also under development. High-frequency phenomena cannot be recorded with this system and conventional analogue apparatus must be used to record them.

CONCLUSIONS

A constant problem in planning large, expensive, and novel equipment of this kind is that both the needs and the abilities change rapidly. The natural reluctance to provide the large capital resources required inevitably means that some needs are certain and urgent before planning can begin. But there is also an inevitable delay between planning and completion, and frequently a further period while complex equipment is set to work smoothly. In these circumstances it is perhaps safest, and certainly easiest, to build equipment which may be of very restricted use when finished and in service. Nonetheless useful this equipment will be; there are few idle pieces of aeronautical research equipment. If equipment is begun in this way, but modified during construction as needs clarify, it never will be complete and this is the worst course of all. The real alternative is to plan the most flexible arrangements possible and to assume within the plan the best available judgments of future needs and techniques, but to omit for the present any uncertain requirements in the actual construction. In Britain an energetic engine industry needs first-class test equipment. It is important to build what will be most needed in the future and not what was wished for a few years ago. Time will show whether sound choices have been made.

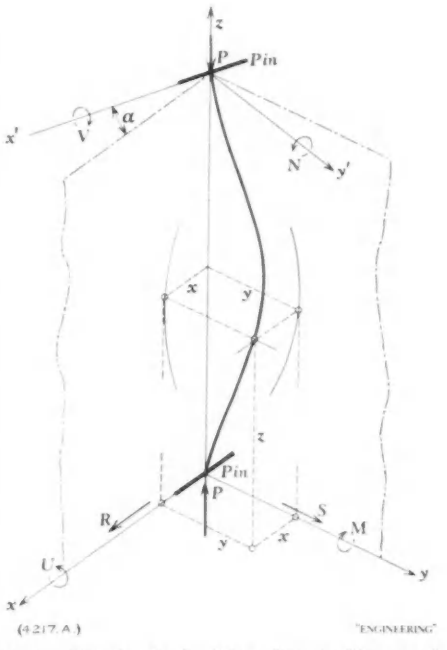


Fig. 1 Notation for buckling of strut with crossed hinges.

COLLAPSING LOAD OF STRUT WITH CROSSED HINGES

By Dr.-Ing. M. J. Gercke

The theory of the stability of struts as usually given in text-books relates to plane buckling and only to specially idealised end conditions. To approach the more general problem of the buckling load P of a strut of length l and flexural rigidity E I, elastically hinged by pins having axes not parallel to each other, the "specific collapsing load"

$$\phi = \frac{P\,l^2}{E\,I}$$

must be established as a function of the angle α between the axes of the pins and the coefficients of "angular fixing"

$$\mu, \nu = (K_m, K_n)\frac{l}{E\,I},$$

where K_m, K_n are the end moments about the pins due to unity end-inclination. Using the conventional bending theory, the differential equation of the projections of the deflected strut may be written as (for notation see Fig. 1):

$$\frac{d^2h}{dz^2} + \frac{\phi}{l^2}\left(h - f + g\frac{z}{l}\right) = 0$$

If h denotes the ordinates x, then $f = \frac{M}{P}$, $g = \left(\frac{M - N\cos\alpha - V\sin\alpha}{P}\right)$; or if the ordinates y, then $f = \frac{U}{P}$ and $g = \left(\frac{U + N\sin\alpha - V\cos\alpha}{P}\right)$

The solution, assuming that the ends are fixed in position ($h = 0$ at $z = 0$, and $z = l$), is

$$h = f\left(1 - \frac{z}{l} - \frac{\sin\left(1 - \frac{z}{l}\right)\sqrt{\phi}}{\sin\sqrt{\phi}}\right) + (f - g)\left(\frac{z}{l} - \frac{\sin\frac{z}{l}\sqrt{\phi}}{\sin\sqrt{\phi}}\right) \quad (1)$$

This equation has to be amended to satisfy the four end conditions that the slopes of the line of bending at the ends shall be perpendicular to the pins and proportional to the end moments about the pins. To fulfil the resulting four end-condition equations, a certain relationship must obtain between their coefficients

$$a = \sqrt{\phi} - \sin\sqrt{\phi}$$
$$b = \sqrt{\phi}\cos\sqrt{\phi} - \sin\sqrt{\varphi}$$

and the parameters μ, ν and α, the value of ϕ thus determined being the specific collapsing load. It has been found as the determinantal stability equation

$$\begin{vmatrix} a\cos\alpha & b & -a\sin\alpha & . \\ b & a\cos\alpha & . & a\sin\alpha \\ a\sin\alpha & . & a\cos\alpha & b - \frac{\phi\sin\sqrt{\phi}}{\nu} \\ . & -a\sin\alpha & b - \frac{\phi\sin\sqrt{\phi}}{\mu} & a\cos\alpha \end{vmatrix} = 0,$$

whence, writing $\frac{a^2 - b^2}{\phi\sin\sqrt{\phi}} = c$, finally gives

$$\sqrt{(\mu c + b)(\nu c + b)} = a\cos\alpha. \quad (2)$$

For convenience in the use of this formula, a, b and c may be plotted against $\sqrt{\phi}$.

RESULTS

The general buckling formula (2) is symmetrical in μ and ν, as would be expected, and is not influenced by the sign of α. For $\alpha = 0$ it can be rewritten as

$$[\mu\nu c + (\mu + \nu)b - \phi\sin\sqrt{\phi}]\,c = 0.$$

Hence, either $c = 0$, consequently $\sqrt{\phi} = 2\pi$, independently of μ and ν, buckling occurring in the plane of the pins, or the term in brackets must be zero. This condition, referring to buckling in a plane perpendicular to the pins, constitutes the generalised Euler formula recently discussed* from which the elementary formulae commonly attributed to Euler can be readily obtained by taking either μ or ν or both as zero or infinity.

If $\alpha = 90$ deg., equation (2) can be split into the two expressions

$$(\mu \text{ or } \nu)\,c + b = 0,$$

due to the fact that there are, for a strut supported by rectangularly crossed pins, two Euler buckling loads which are equal, respectively, to the critical loads for the plane buckling of a strut *encastré* at one end and elastically hinged at the other; the degrees of fixing are μ or ν, respectively.

Between the two pairs of values of $\sqrt{\phi}$ at $\alpha = 0$ and $\alpha = 90$ deg. in any case two curves of

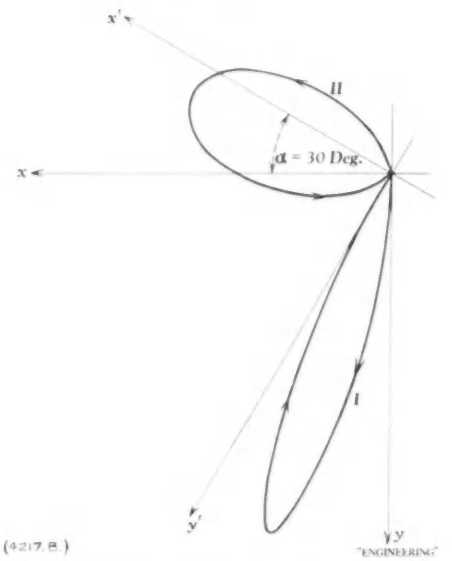


Fig. 2 Two potential deflection lines for conditions stated.

$\sqrt{\phi}$ versus α are defined by equation (2). Such curves of the specific collapsing load have been computed for $\mu = 0$, 1, 2, 10 and infinity, assuming (i) $\nu = 0$, (ii) $\nu = \mu$. For values of $\mu = \nu$ in excess of about 20 the difference between the curves is negligibly small. Basically there are always two critical loads for any given set of values of α, μ and ν, but for practical purposes only the lower is of interest; both are primary buckling loads. If $\mu = \nu = 0$, then $\cos\alpha = -\frac{b}{a}$

This, as can easily be shown by substituting $\tan^2\alpha$ for $\cos\alpha$, is the relationship given by Ashwell* for the freely-hinged strut.

END MOMENTS AND FORCES

To ascertain, additionally, the geometrical form of the strut when it buckles, equations of the end moments and forces have been considered. From them it follows that the strut with crossed elastic hinges is held by the critical load in such a state of elastically unstable distortion that the product of the end-moment

* See ENGINEERING, vol. 176, pages 67 to 70 (1953).

* See ENGINEERING, vol. 169, page 709 (1950).

ratios $\frac{N}{M}$ and $\frac{V}{U}$ equals the ratio $\frac{\nu}{\mu}$ of the degrees of angular fixing.

Further, the line of action of the reactive end force $\sqrt{R^2 + S^2}$ is found to include an angle ψ with the x-axis for which

$$\tan \psi = \text{cotan } \alpha + \sqrt{\frac{\nu c + b}{\mu c + b}} \text{ cosec } \alpha .$$

Thus for the validity of equation (2) which was derived on the assumption that the ends were fixed in position, the end joints must prevent any possibility of lateral displacement of the ends in the direction of ψ.

A numerical example has been worked out, assuming $\alpha = 30$ deg., $\mu = 3$, $\nu = 1$. The values of $\sqrt{\phi}$ consistent with equation (2) are then 4·135 and 5·998. The deflection lines under the critical loads $P = 17{\cdot}10 \frac{EI}{l^2}$ and $P = 35{\cdot}98 \frac{EI}{l^2}$, shown in Fig. 2 by their projections on the xy-plane "p" and "s" respectively with the arrows pointing from the end $z = 0$, $\mu = 3$ to the end $z = l$, $\nu = 1$ of the strut, differ remarkably in that the principal deflection line "p" remains within the angular space between the yz- and $y'z$-planes, whereas curve "s" is not confined to the corresponding space between the xz- and $x'z$-planes.

Copies of the full paper of which the above is a digest are obtainable from the Publisher, ENGINEERING, 35 & 36 Bedford Street, Strand, London, W.C.2, price 25s. each, post free.

RECEPTANCES APPLIED TO OSCILLATIONS IN PIPE SYSTEMS

By Professor W. J. Duncan, C.B.E., D.SC., F.R.S.*

In mechanics the word "receptance" has come to mean a dynamic flexibility, i.e., the amplitude of the linear displacement induced by a simple harmonic force of unit amplitude and given frequency. However, in applications of the same general concept to the oscillations of fluids in pipes it is very convenient to define receptance as the amplitude of the volume displacement induced by an applied sinusoidal pressure of unit amplitude. Thus if $\beta(\omega)$ is the receptance corresponding to the frequency $\frac{\omega}{2\pi}$ then

$$\beta(\omega) = \frac{\text{amplitude of volume displacement}}{\text{amplitude of simple harmonic pressure}}.$$

A receptance is called "direct" when the volume displacement is measured at the place where the pressure is applied but it is also essential to employ "cross receptances" for which the volume displacement is measured at some remote point.

As a simple example to illustrate the utility of this concept, take the case where n pipes meet at a junction. Then the natural frequencies of oscillation of the system are such that the sum of the receptances at the junction is zero, i.e.,

$$\sum_{r=1}^{n} \beta_r(\omega) = 0,$$

where $\beta_r(\omega)$ is the direct receptance for the r^{th} pipe for pressure applied at the point of junction.

When the fluid is a liquid and the frequency not too high it will be a legitimate approximation to treat the pipes as rigid. In this case any receptance of a simple pipe will be expressible in the form

$$\beta = \frac{1}{\sigma - \omega^2 \mu}$$

where σ is the constant "stiffness" and μ is the constant "inertia." These are easily calculable in any given case. When account is taken of the influence of viscosity the receptances become complex numbers and it is then profitable to extend the definition to cover applied pressures the time dependence of which is of the damped sinusoidal type.

Copies of the full paper of which the above is a digest are obtainable from the Publisher, ENGINEERING, 35 & 36 Bedford Street, Strand, London, W.C.2, price 20s. each, post free.

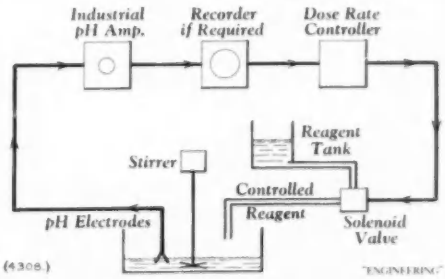
* Department of Aeronautics and Fluid Mechanics, in the University of Glasgow.

POLLUTION AND *p*H

In recent years there have been considerable improvements in the reliability and accuracy of *p*H measuring equipment. (A *p*H meter is normally an electrolytic device, which measures the concentration of hydrogen ions and hence the acidity of a solution.) At the same time, owing to the increased quantities of effluent discharged into rivers, the importance of *p*H control is increasing. As a result of these developments there is now more widespread knowledge of the nature of *p*H and of the details which are important when installing or maintaining such apparatus. It is known that factors such as crystalline deposits on electrodes or slightly damp insulation may give erroneous readings. An insulation check with an ordinary "Megger" is unsatisfactory because a normally good reading on this instrument is virtually a short circuit in *p*H measurement where the insulation resistance required is of the order of thousands of megohms. Plant operators do not always help instrument maintenance and have been known to close down a *p*H meter as well as the plant. This sort of treatment obviously calls for the use of weatherproof housings.

For those buying new equipment who do not themselves employ instrument application specialists it is helpful to consult manufacturers at an early stage because they will be able to advise on the relative merits of different control systems and on the practical aspects previously mentioned. Systems designed in this way are more likely to be successful than where the instruments are supplied as an afterthought.

An interesting addition to the existing equipment has appeared in the form of a simplified *p*H controller marketed by A. M. Lock and Company, Limited, and has been designed for use with measuring equipment made by the Cambridge firm of W. G. Pye and Company, Limited. With continuous processes it is frequently necessary to keep *p*H value within reasonable limits or alternatively when using discontinuous operation a batch of process material may have to be brought to a desired *p*H. In these circumstances the Lock control system achieves the desired result for less capital outlay than in the case of systems designed for controlling to very precise values. Such precision is not always necessary. The accompanying diagram shows the layout of equipment required for a batch process.



Lock *p*H dose rate controller applied to the control of a batch process. When *p*H approaches the desired value the reagent valve cycles open-shut until the correct point is reached. This prevents overshoot.

The new equipment produced by Lock and Company, Limited, 79 Union-street, Oldham, Lancashire, consists of their dose rate controller and two types of control valves. The controller does not operate until the measurement goes outside the set limits (adjustable). When this happens the first of two timers come into operation and energises a reversible motorised control valve for a variable preset time (adjustable 0 to 30 seconds); the direction of drive depends on the measured value. The second adjustable timer (range 0 to 5 minutes) switches the motor off for another preset time and at the end of this period the *p*H is measured again. The cycle repeats until the measured value falls within the required limits. The valve comprises a motor and a gearbox which drives a cam compressing a rubber tube through which the reagent flows. Such a valve is capable of handling slurries and corrosive reagents. For batch operation solenoid pinch valves are used and these are normally open until the *p*H gets near the required value. They are then cycled open and shut until the desired result is obtained.

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TRANSISTORS FOR HIGHER TEMPERATURES

If transitors are to replace vacuum tubes—and their small size, reliability, and low power consumption makes this desirable—it is necessary that their sensitivity to temperature be overcome and their properties at high frequencies improved. The marked temperature dependence is a property of the semi-conducting material from which the transistor is made. Transistors employing germanium cannot operate satisfactorily at temperatures above 70 deg. C. Improvements can be achieved by the use of compensating circuits, and by the use of materials that are less temperature sensitive.

Transistors are chiefly made from germanium, but silicon, which has a better high temperature performance, is becoming more widely used. Recently Bell Telephone Laboratories, New York, announced that they were experimenting with a *p-n-i-p* silicon power transistor capable of providing an output of 5 watts at 10 Mc/s. The construction of the transistor is more complex than the usual *p-n-p* type (ENGINEERING, vol. 183, page 690, May 31, 1957) since it embodies a near-intrinsic or "neutral" layer of silicon between the collector and the other elements. However, it is hoped that improvements in the diffusion process will result in a transistor that is reliable and easy to make.

As the temperature limit of silicon transistors is at about 160 deg. C., research is being made on new materials with higher temperature limits. Gallium arsenide, which can be used at 450 deg. C., is being studied at the David Sarnoff Research Centre of the Radio Corporation of America, Princeton, New Jersey. Simple gallium arsenide devices have yielded results that compare favourably with similar germanium and silicon devices, but the present cost of the material is high. For higher temperatures it appears possible that diamonds may be used.

Although carbon in the form of diamond is a non-conductor, certain of the rare blue diamonds are semi-conductors. Work at the Diamond Research Laboratory, Johannesburg, South Africa, is directed at introducing small amounts of aluminium into common diamonds by diffusion at high temperatures. With this technique it is hoped that common diamonds will be made to exhibit semi-conducting properties. The small size of the transistor makes fabrication from diamonds less costly than might be expected.

Book Reviews

GUIDES TO MISSILE AND ROCKET DESIGN

Rocket Propulsion Elements: An Introduction to the Engineering of Rockets. By GEORGE P. SUTTON. Second edition. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (10.25 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (82*s.*)

Aerodynamics, Propulsion, Structures and Design Practice. By E. ARTHUR BONNEY, MAURICE J. ZUCROW and CARL W. BESSERER. Part of the series on "Principles of Guided Missile Design." *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.* (10 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (75*s.*)

Atomic energy, guided missiles and space-flight have captured the public imagination more than any other post-war scientific topics. There have been noteworthy practical achievements in the first two subjects and it might be expected that they would be covered by quite a wide comprehensive technical literature. In the case of atomic energy, the number of technical works is quite appreciable and is growing rapidly. A very far-reaching series of international monographs has just been initiated, and original papers are printed in a great number of reputable technical journals.

Guided missiles also have a large amount of literature devoted to them, but most of it, on close examination, is found to be repetitious, and the content of original material is low. The reason is that most of the original work is still under security "wraps" and the process of declassification is a slow one. The propulsion unit has been better served than any other aspect of guided-missile design (with the possible exception of supersonic aerodynamics). The three types of unit in use are the turbojet, ramjet and rocket. Several excellent works have been devoted to the turbojet; the ramjet, unfortunately, still awaits an author; and two good books have appeared on rockets (only English works are referred to—at least one good technical book in Russian has been published on liquid-propellent rockets). Only one work covering both liquid and solid-propellent rockets has yet appeared. This is *Rocket Propulsion Elements*, by G. P. Sutton, the first edition of which appeared in 1949. At that time it contained much material that would, in this country, have been considered as "classified." It has become, naturally enough, the standard work on the subject and this recently-issued second edition is very welcome.

The text has been increased by about 60 per cent., mainly by the inclusion of extra material on solid-propellent motors and an extra chapter on heat transfer. The work is very well planned, dealing with both theoretical and practical aspects of rocketry. An even technical standard is maintained throughout the clearly-written text, and the book can be strongly recommended to the student, the new entrant to the field of rockets, or the old hand. The few errors in the first edition have been corrected, although a number more (mostly due to bad proof-reading) have crept in; fortunately, these are mostly quite minor and should worry no one. Illustrations, type and general production are up to the usual high standard associated with John Wiley, the publishers. The excellent 46 page bibliography will be particularly useful to the worker in the field.

Other aspects of guided missiles such as guidance, structures, launching techniques and testing have been poorly covered in the literature and the announcement last year of a series of books to cover all aspects of guided missile design was received with great interest in the missile industry. This series was commented on in general in ENGINEERING, Feb. 22, page 227, so here we are concerned only with the second volume. The aim of the series, according to the editor, is to "endeavour to set forth the underlying principles of guided missile technology." In any collective work of this nature the editor must be sure that each contributor fully understands the general aim and writes accordingly. In this respect the present volume is not wholly successful. Each section has been written by an acknowledged expert, and taken by itself is excellent.

Bonney presents general supersonic aerodynamic information of value to engineers engaged in guided missile design but who are not themselves trained aerodynamicists. This is a clear and concise account of the simple theory with applications to the various aspects of missile external aerodynamics. Of questionable usefulness are the paragraphs scattered throughout the text on the writing of various types of report—for example, aerodynamic load reports and performance reports; each organisation has its own methods of dealing with such reports and the information appears to be superfluous.

"Propulsion," by Zucrow, is the longest section of the book and is noteworthy for its inclusion of the best unclassified treatment of the ramjet that the present reviewer has seen. Other chapters deal with gas dynamics, flow through nozzles and diffusers, the turbojet and the rocket. Both of these first two sections are excellent and fall into line with the author's expressed intent of providing the basic principles, but it must be admitted that they contain little that cannot be found in the standard texts.

In the last section ("Structures and Design Practice," by Besserer), on the other hand, the author states "Engineering fundamentals are not included since it is assumed that users are proficient in the application of basic principles." Hence one can look in vain for information on the basic design of the main missile structure, and thus this section is out of line with the other two. Instead the author concentrates on some of the detail design problems, and has produced, for the expert at least, the most interesting and rewarding section of the book. He deals with general design criteria, including properties of constructional materials, and continues with design for environmental conditions, reliability concepts, packaging engineering and composite design. This last chapter deals largely with production and costing.

Each of the sections is provided with a good bibliography (nearly 1,000 items in all); there is an adequate index and the production is first-rate. As present-day technical books go, it is very good value for money, but by its heterogeneous nature both student and professional will, in places, find the work rather disappointing—although all connected with or interested in the missile industry will find in it much interesting and useful material.

WHY WORK?

Management, Labour and Community. Edited by D. CLEGHORN THOMSON. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.2.* (35*s.*)

Mr. Nigel Balchin, who is better known as a novelist than as the industrial psychologist he was when he started his working life, tells a revealing story in his valuably sceptical contribution to this collection of essays. A Cabinet Minister, visiting a mine, had a notorious absentee brought before him. To the Minister's question, "They tell me you turn up here four days a week. Why is that?" The miner replied, "Because I find I can't earn as much money as I need in three?" If we are honest with ourselves we must admit that this is the logical answer that would be given by a majority of workers in our mines and factories; and the manager who forgets it is likely to run into trouble.

The problem in so much of modern industry is that it is difficult to relate the tasks which the individual worker performs in it to the rising standard of living which he expects to obtain from his earnings; and, in many cases, as Dr. Jonathan Gould points out in his interesting chapter on "Dealing with Prejudice," there may actually be social prejudice against that expansion of production without which a rising standard is impossible. This is the social environment in which industrial management has to operate and it is dealt with in this book in a number of its chapters, many of which were originally papers read to an Industrial Welfare Society conference. The contributors include social scientists, technical college teachers of management studies and a number of managers, all, with the exception of one, from nationalised undertakings, chiefly the Central Electricity Authority, of which the editor is director of welfare.

Two of the most interesting, as well as the most lucidly written, chapters are by the Earl of Halsbury and Sir John Maud and they deal with the respective advantages of science and arts graduates and the relationship of the expert to the manager. The practical managers are best when they describe concrete things, such as joint consultation or wage negotiations. On training methods there is a perceptive chapter by Mr. C. E. J. de Leeuw and useful descriptions of methods by Miss Elizabeth Sidney (on interviewing) and by Mr. John Munro Fraser (on human relations).

The ideas in this book are no doubt a long way from some of the highly speculative ideas of the management theorists of 25 years ago; but they are the result both of research and of experience in management training. They would form a useful background to anyone with management experience coming for the first time to the idea of formal education and training for management, if such a backwoodsman still exists anywhere. At the same time they should help those already engaged in this still experimental activity to assess the value of what they are doing and the methods by which they are doing it.

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NEW BOOKS

Publications released by The British Electrical and Allied Industries Research Association, *Thorncroft Manor, Dorking-road, Leatherhead, Surrey*:

Unified Treatment of Linear Systems—1, by H. PELZER, L/T332 (10*s.* 6*d.*); The Structure and Properties of Cadmium Titanate and Sodium Tantalate, by J. L. MILES, L/T333 (15*s.*); The Mechanism of Uniform Field Breakdown in Hydrogen, by A. WILKES, L/T335 (6*s.*); Oscillations of Dielectrics and Plasma, by H. PELZER, L/T337 (7*s.* 6*d.*) Surge Recording at High Street (Manchester) 33 kV Substation, by E. L. WHITE, S/T78 (21*s.*); Surge Recording at Portobello 132 kV Substation, by E. L. WHITE, S/T82 (10*s.* 6*d.*)

Rubber in Engineering. Proceedings of a Conference held at the Institution of Electrical Engineers, on September 26, 1956. *The Natural Rubber Development Board, Market Buildings, Mark-lane, London, E.C.3.* (*Gratis.*)

The five papers presented at the Conference and the discussions they inspired, have now been published in book form. The papers comprised "Rubber Must be Used Correctly," by Dr. W. J. S. Naunton;

" Load-Deflection Relations and Surface Strain Distributions for Flat Rubber Pads," by Dr. A. N. Gent; " The Use of Rubber in Heavy Engineering," by Mr. S. W. Marsh; " Dynamic Fatigue Life of Rubber Components," by Mr. P. W. Turner; and " Rubber in Agriculture," by Mr. S. J. Wright. The introductory address of Mr. H. H. Facer, chairman of the Natural Rubber Development Board is also included. The book contains 160 pages and upwards of 100 illustrations, and constitutes a companion volume to the Board's *What Every Engineer Should Know about Rubber* and *Rubber in Automobile Engineering*.

Materials and Processes in Manufacturing. By E. PAUL DEGARMO. *The Macmillan Company, 60 Fifth-avenue, New York 11, N.Y., U.S.A.* (8.50 *dols.*); and *The Macmillan Company (New York), 10 South Audley-street, London, W.1.* (52*s.*)

Professor DeGarmo's book is primarily intended for engineering students and the subject matter is divided into five main sections. The first deals with " Materials," and in it the nature and properties of metals and alloys, and of plastics are considered. Parts two and three describe metal casting and forming, and machining processes, and part four, welding and allied processes. The final section deals with processes and techniques related to manufacturing and, among the subjects discussed, are layout, jigs and fixtures, decorative and protective surface treatments, mass-production tools and techniques, and the planning of manufacturing operations. Many of the processes and methods described are illustrated by selected drawings and photographs which help the student to understand the steps involved in the production of particular articles.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Torquemeter. BULOVA RESEARCH & DEVELOPMENT LABORATORIES, INC., Department of Government and Industrial Sales, Woodside 77, New York. A reversible torque device that can be used either as a driving force or to oppose an external driving force. Calibrated measurements of speed and torque are provided up to 100 r.p.m. and 40 oz.-in. Illustrated leaflet.

Voltage Regulator. STANDARD TELEPHONES & CABLES LTD., Transmission Division, North Woolwich, London, E.16. Electro-mechanical regulator for loads of 2 kVA and 4 kVA that reduce a 15 per cent. variation in the supply to 1 per cent. Voltage changes are corrected by motor-driven brushgear traversing an auto-transformer winding. Illustrated leaflet.

School of Electronics. AUTOMATIC TELEPHONE & ELECTRIC CO. LTD., Strowger Works, Liverpool, 7. Details of four-month and academic-year full-time courses on electronics. Students of graduate standard or equivalent are accepted and are introduced to industrial design and manufacturing techniques. Illustrated brochure.

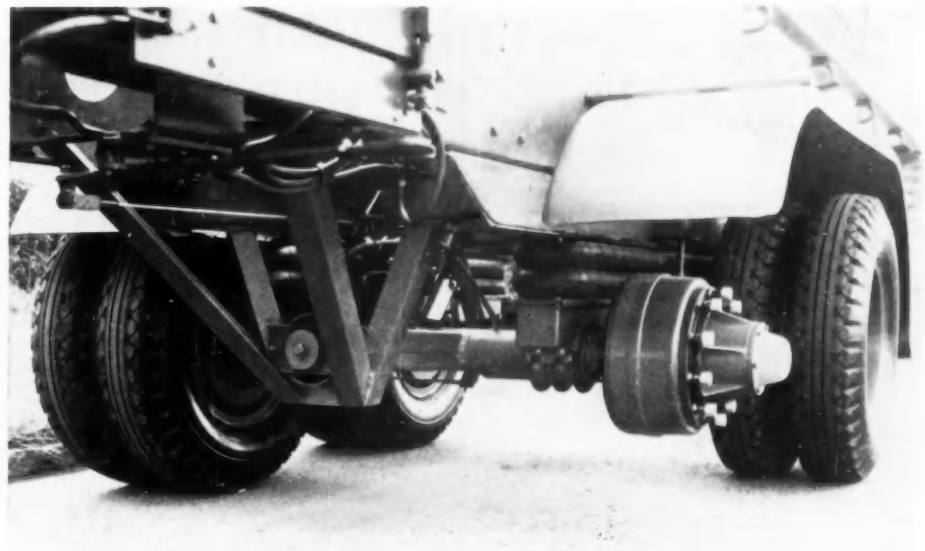
Telephone Exchange. AUTOMATIC TELEPHONE & ELECTRIC CO. LTD., Strowger Works, Liverpool, 7. Private automatic branch exchange type 211, extensible from 100 lines upwards. The system comprises selector equipment for internal telephones, and for links between such extensions and the public exchange. Illustrated brochure.

Oil-Filled Current Transformers. ENGLISH ELECTRIC CO. LTD., Queens House, Kingsway, London, W.C.2. Publications SG/238 and SG/240 deal with outdoor and indoor current transformers, respectively. The former for voltages from 33 kV to 165 kV, the latter for from 0·66 kV to 11 kV. Illustrated brochure and illustrated leaflet.

Constant-Voltage Devices. CLAUDE LYONS LTD., Stabiliser Division, Ware-road, Hoddesdon, Herts. Mains transformer with electronic unit that automatically changes the input tapping when the mains voltage varies by more than 5 per cent. The 200 to 250 volt range is rated at 575 VA. Illustrated leaflet.

Electric Heaters. BRITISH THOMSON-HOUSTON CO. LTD., Rugby. Electric heaters for liquid and space heating. Single and three-phase types, and heaters suitable for the rearing of piglets or chicks. Illustrated leaflet.

Electrical Test Equipment. FOSTER TRANSFORMERS LTD., South Wimbledon, London, S.W.19. Photographs of transformers, test equipment, and regulating equipment produced. Illustrated leaflet.



One wheel has been removed from the Dyson air-suspension semi-trailer to show the air bags used in place of conventional springs. Body height remains constant whatever the loading conditions.

CARRYING THE LOAD ON AIR

SELF-ADJUSTING VEHICLE SUSPENSION

Because of the great difference between the loaded and unloaded weights of a goods road vehicle, conventional springing, which must obviously be designed for maximum load conditions, is too stiff when unloaded. The resultant rough riding of the vehicle when light is responsible for heavy wear and tear. In addition it may, in the case of a light load, cause damage to the goods being carried. Self-adjusting suspension, which sets itself automatically to suit load conditions, is clearly desirable. It is such a mechanism which R. A. Dyson and Company, Limited, Grafton-street, Liverpool, 8, have now put into production.

Based on a design developed by the General Tire and Rubber Company of America, the suspension utilises rubber air bags in place of laminated steel springs, and incorporates automatic adjustment for both load and height of vehicle platform. Using air bags made under licence by the Andre Rubber Company, Limited, the suspension gear has a slight weight advantage compared with conventional springs, and because of the greatly improved riding conditions offers considerable opportunities for weight saving in the vehicle body. There are no parts in the suspension requiring lubrication, and routine maintenance is negligible.

As at present in production, the pneumatic suspension is fitted to a Dyson semi-trailer, 25 ft. long and 7 ft. 6 in. wide, capable of carrying payloads of 16/17 tons. It can be used with any tractor fitted with two-line air-pressure braking, no modifications to the tractor being necessary. Details of the body work can, of course, be varied to suit users, and the suspension system is applicable to other types of semi-trailer and trailer.

AIR SUPPLIED BY THE VEHICLE

The air bags are constructed of fabric and rubber like a tubeless tyre, and Neoprene covered so as to be resistant to oil, petrol and numerous other liquids. They are mounted between the vehicle chassis and hollow steel connecting beams which locate and retain the axles and also act as air compression chambers. Chassisless vehicles can also be carried on the air bags, the upper fixing in that case being direct to a suitable body member. The air bags are inflated from the vehicle braking system reservoir through a suspension reservoir. A special valve in the feed ensures that in the unlikely event of failure in the suspension system the brakes are completely isolated from it, thus providing for full braking safety.

Movement-limiting rubber bumpers are fitted inside the air bags, and rebound-limiting rods with rubber buffers are located between the compression chamber and the chassis frame. A hydraulic shock absorber is fitted in line with the centre of each air bag. Each axle has a torque arm which carries a large rubber bush, mounted in a framework suspended from the chassis cross-member. These bushes absorb all the braking torque and side thrust.

AUTOMATIC ADJUSTMENT

Height-control valves, connected by links and levers, operate according to the height of the vehicle body above the axles, and adjust the pressure of the air in the bags accordingly. Thus, if the vehicle body height falls because a load is placed on it, the valves increase the pressure of the air in the bags and compression chambers and so raise the body again until the set height is reached. An important feature of this arrangement is that since there are two independent height-control valves, uneven loading of the vehicle is compensated for automatically by increasing or decreasing the pressure in one bag according to the individual load, and the vehicle body remains level under all conditions. The body height is thus constant, whether loaded or unloaded, and irrespective of how the load has been distributed, the only possible variation in body height coming from the negligible deflection of the tyres. The pressure in the air bags varies from about 5 lb. per square inch in the two when unloaded to about 45 lb. when the full load is on the vehicle.

SAFETY UNDER ALL CONDITIONS

As already stated, the vehicle braking is protected in the event of failure in the air suspension. If the air should leak or even if one or both of the bags should become damaged and cease to be airtight, there is no danger to the vehicle, which could proceed safely with the internal bumpers taking the load.

DIRECT-COOLED STATORS FOR 200 MW ALTERNATORS

REDUCED DIMENSIONS WILL AID TRANSPORT

The General Electric Company, Limited, Kingsway, London, W.C.2, have prepared designs incorporating direct cooling of the stator windings of alternators with outputs in excess of about 200 MW. Although this departure by itself will lead to no increase in specific output it will enable the dimensions of the slots and core plates to be reduced; and, in spite of certain complications, will therefore be justified when the weight approaches the maximum transport limits of 150 to 160 tons. In fact, the object of the development is to produce an efficient cooling arrangement which is sound both mechanically and electrically with a minimum of disturbance to well-established manufacturing methods.

The arrangement used is shown diagrammatically in Fig. 1, the stator windings being represented by thick lines with each phase divided electrically into two parallel circuits. Water is used for the cooling, since its high thermal capacity and low viscosity allow small ducts to be used. It can therefore flow through several conductors in series thus reducing the number of tapping points on the winding to a minimum; and limiting the maximum hydraulic pressure to a value below that of the hydrogen in the casing.

As will be seen, the water flows into both ends of each phase winding and is discharged at the centre point of each half phase, thereby giving 12 cooling circuits in parallel through the stator. The terminal bushings *a* through which the water passes into the casing have hollow stems, so that the cooling which results increase their current carrying capacity and prevents expansion strains. The warm water from the windings is discharged through three small bushings *b* which are connected to the mid-points of each phase by insulated metal pipes with brazed joints. There is a complete absence of unusual insulation features and the leakage surfaces are normal.

In order to reduce the voltage between the bushings and the earthed water circulating pump and heat exchanger, resistance columns are provided in the foundation block. These simply consist of straight tubes of insulating material of appropriate length and diameter and contain a column of water of the required electrical resistance.

STATOR CONDUCTOR DESIGN

As shown in Fig. 2, the stator conductor consists of a number of thin-walled copper tubes above and below which are placed solid copper strips with only light insulation interposed. The water circulates through all the tubes in parallel, the quantity being such that the heat both in them and in the strips is absorbed. Since the heat is transferred from the strips to the tube over a wide area, the temperature gradient across the insulation is negligible and the copper in the conductor at any section is at about the same temperature. This combination of tubes and strips allows the greater part of the current to be carried effectively by the thin insulated laminations and the water to flow in a few channels of reasonably good shape with a low pressure drop. The remainder of the current is carried by the tube walls.

ARRANGEMENT OF STATOR CONDUCTORS

The method of transposing the stator conductors to reduce the eddy current losses, which is generally employed by the General Electric Company, will also be used for the directly cooled windings, with the modification that the strips and tubes at both ends of the stator will follow round from top to bottom in sequence. This arrangement is desirable with a direct-cooled winding in order to facilitate the jointing of the tubes. It also eliminates the need for the "jumpers," which are normally used to transfer the required number of strips from the top to the bottom of the stack of laminations when making the joints to the next coil.

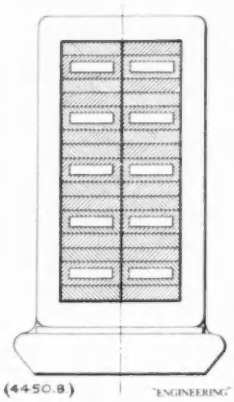


Fig. 2 (left) Section through a stator conductor of a direct-cooled alternator.

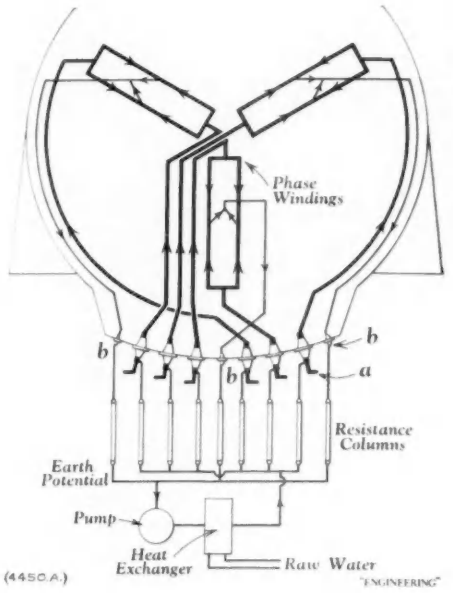


Fig. 1 (right) Diagram of the cooling circuit used for the stator windings of a General Electric direct-cooled alternator.

a **Terminal bushings.**
b **Discharge bushings.**

As will have been gathered, the insulation of the windings is the same as that which has been used on the firm's alternators for many years. The appearance of the stator, too, only differs from the conventional form at the points where the warm-water discharge pipes leave the windings; although here again, a standard insulation technique is employed. For various reasons the output of the large machines on which stator cooling will be employed will not be accompanied by a corresponding increase in the generator voltage. The stator current will therefore be appreciably higher than normal, being of the order of 10,000 amperes for a 300 MW alternator. The difficulty of using a naturally cooled, or even a direct gas-cooled, terminal bushing for a current of this value is overcome by employing a water-cooled bushing, such as that incorporated in the machine which we have just described.

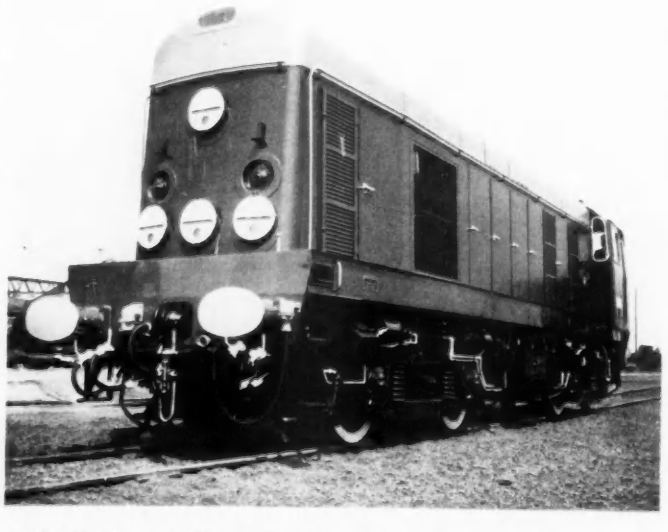
RAILWAY MODERNISATION

Main Line Mixed Traffic Diesel-Electric Locomotives

The first of the main line Diesel-electric locomotives completed under the British Railways modernisation plan was formally handed over at the Vulcan Foundry Works, Newton-le-Willows, by Sir George H. Nelson to Lord Rusholme on Monday, June 3. The opportunity was also taken to exhibit Diesel, Diesel-electric and electric locomotives, now under construction at the works.

The type "A" locomotive is rated at 1,000 h.p. mixed traffic operation, and the group will be numbered under the new system, from D8000 onwards. The wheel arrangement is Bo-Bo, giving an adhesive weight of 72 tons (also, of course, the weight in working order) and a maximum axle load of 18 tons. The length over the buffer beams is 43 ft. and the overall width, 8 ft. 9 in. Maximum tractive effort is 42,000 lb., and the continuous rated effort 19,500 lb. with a maximum service speed of 75 m.p.h.

The engine used is the English Electric 8SVT Mark II, rated at 1,000 h.p. at 850 r.p.m. This is an eight-cylinder unit with the cylinders arranged in V formation, the included angle being 45 deg. It is a four-stroke engine, supercharged by two Napier exhaust-gas driven turbochargers. The main generator is bolted solidly to the engine and, together with the overhung auxiliary generator, forms an integral power unit; the whole group is mounted on resilient bearers. The main generator is a direct-current self-ventilated single-bearing machine, with a continuous rating of 1,070 amp. at 600 volts. The output provides the power for driving the four traction motors, the range being obtained by simultaneous control of the main engine speed and the main generator field excitation.



British Railways 1,000 h.p. Diesel-electric locomotive. It has a length over the buffer beams of 43 ft., and a maximum service speed of 75 m.p.h.

The main radiator

fan is driven by a direct shaft from the Diesel engine, and the auxiliaries, which include an exhauster, a compressor and two traction motor blowers, are all driven from the 110 volt direct-current supply obtained from the auxiliary generator. The radiator fan is roof mounted, and the drive from the engine shaft is through a right-angled gearbox. The traction motors are axle-hung and nose-suspended, driving through single-reduction gearing. They have a continuous rating of 600 amperes at a nominal voltage of 300. Provision is made for field weakening by diverter resistances.

Most of the control gear is housed in a single cubicle which faces into the cab and is placed transversely across the locomotive. Wheel slip is indicated to the driver by a warning light, and the tractive effort is automatically reduced. The locomotive superstructure is of the bonnet type with a driving cab at one end only. Doors are provided along the body sides to give access to the Diesel engine equipment.

The end-frame is made up of four channel longitudinals divided into two pairs, each pair being joined at the top and bottom by plating, thereby forming two box sections. The centre portions of these box sections are sealed off to form two fuel tanks. Drag boxes are welded at both ends of the end-frame to carry the drawgear which is of the standard British Railways screw coupling type, with provision for fitting buck-eye couplers. The bogie frames are of fabricated construction, the sole bars being welded to give a box section, with a fabricated transom and head stocks riveted to them to complete the frame. A single bolster riding in each bogie transmits the load from the superstructure. The bolster is carried on semi-elliptic laminated springs which are in turn carried on a swing plank. The swing plank is supported from the bogie frame by inclined swing links. Nests of coil springs located between the inside of the bogie frame and the top side of the equaliser beams provide springing between the frame and the road wheels, and the forged steel equaliser beams in turn are hung from the roller-bearing axle-boxes.

The brake gear used is the Oerlikon type manufactured by Davies and Metcalfe. At each driving position there are two brake handles, one for the locomotive air brake and the other for the vacuum train brake. A dead-man's pedal is provided at each driving position and also a pedal for the sanding gear.

As the locomotive is intended for mixed traffic work, no provision for train heating has been included, but four kilowatts of cab heating can be switched on, and a special heater supplies warm air to the driver's feet. A breakfast cooker is also provided in the cab.

STEELWORKS LOCOMOTIVES

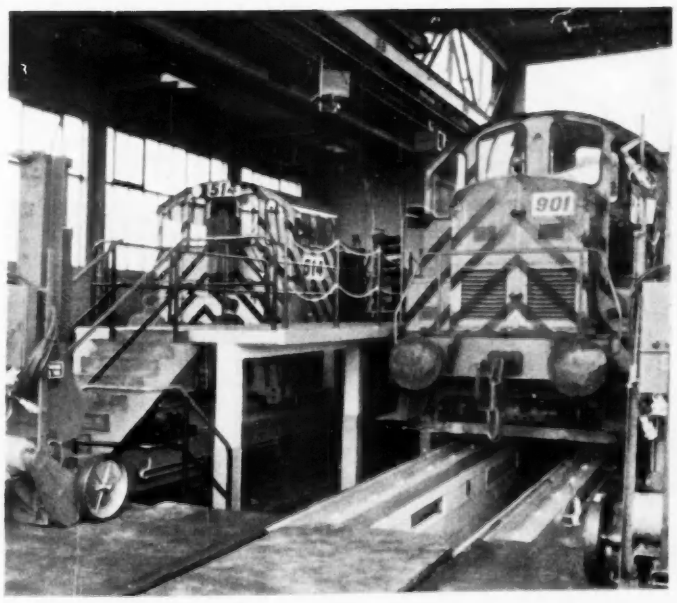
Locomotives that are used for internal operations in steelworks are subjected to very arduous conditions. Consequently it is very necessary to include good service facilities for all types. Some figures have recently been made available of the operation performance of some Diesel-electric locomotives owned by the Steel Company of Wales, and built by Brush Traction Limited, at Loughborough.

Of the original fleet of steam locomotives in use at the Abbey and Margam works, 16 still remain, and of these, three are more than 50 years old. The most recent were built in 1951. Diesel-mechanical locomotives were introduced in 1948 and Diesel-electric in 1950 when five American Alco Bo-Bo locomotives of 660 h.p. were purchased. The first Brush Diesel-electrics were built in 1951 and there are now some 23 of this make in use ranging from 300 h.p. to 515 h.p. Three of 660 h.p. are on order. The controller is in touch with all locomotives by dial radio-telephone.

For servicing, a locomotive shed has been built which has four roads, each equipped with inspection pits. In addition there are galleries at footplate level and side pits for the inspection of the external gear. Facilities include a six ton overhead crane in conjunction with which there is an opening measuring 9 ft. by 6 ft. in the platform (which is normally covered by a grid) to allow crane loads to be lowered to pitside level, and also electro hydraulic jacks mounted on wheels for lifting items up to three tons in weight.

At the end of the shop are located the offices and stores together with a battery charging room, a fitting shop and a fuel injector servicing room. Since the servicing is run on a 24 hour basis, there is also an amenity section which includes a mess room, drying and locker rooms. Power-operated roller shutter doors close the entrances to the four roads.

The inspection pits between the rails are 4 ft. 3 in. deep below rail level. They have tiled sides and are lit by built-in fluorescent lights. The access spaces between the roads are 2 ft. 9 in. below rail level. A planned system of maintenance is in operation, in which certain work is carried out on each locomotive after 300 engine running hours. In addition a complete overhaul is given after every 7,000 hours. Emergency breakdowns have to be dealt with as they occur.



Service shed showing pits and lighting for underneath inspection.

The two tables give performance figures for the four different categories of locomotive. The availability figures given in Table I cover the year 1956; those of operating costs, given in Table II were taken over the period September, 1955, to September, 1956. Details of the four locomotive classes are given in Table III. Class 500 is used for general shunting duties throughout the works, and its heaviest job is handling trains of up to 12 wagons of 42 tons capacity carrying coiled strip. Such a train has a gross weight of 720 tons.

Class 700 are mainly used for ingot traffic. As the bogies carrying the ingots and moulds have roller bearings and are not fitted with brakes, a heavy locomotive with first class braking is essential. They are also used for moving ladles and slag pots; for the latter duty, trains with a gross weight of 500 tons have to be moved up a 1 to 70 gradient. Class 710 are used for similar duties but, being lighter, cannot handle trains of the same size. Class 900 are also used on these duties, as well as all heavy shunting, and can shift correspondingly larger trains.

TABLE I.—*Availability: Year* 1956

Class	500	700	710	900
Running hours*	42,594	22,283	8,120	18,768
Breakdown hours	382	135	349	200
No. of shifts worked	5,372	1,032	2,829	2,371
Shifts locos. unmanned	2,500	3,360	465	923

* This figure includes meal-breaks and shift changes.

TABLE II.—*Operating Costs in shillings and pence: September, 1955, to September, 1956*

Class	500	700	710	900
Operating hours	41,251	20,484	7,932	18,263
Fuel and oil	1/5·7	1/10·0	2/1·5	2/11·6
Repairs and maintenance	6/9·0	17/4·3	22/0·5	9/7·2
Others	3/1·0	3/7·0	3/7·1	3/8·2
Total operating cost per hour	11/3·7	22/9·3	27/9·1	16/3·0

Wages have not been included as they will vary according to local conditions.

TABLE III.—*Locomotive Classes*

Class	Wheel arrangement	Engine, h.p.	Tractive effort	Weight in working order
500	0-4-0	300	24,000 lb. at 1¼ m.p.h.	42 tons
700	0-6-0	480	34,000 lb. at 2¼ m.p.h.	58 tons
710	0-6-0	355	32,000 lb. at 1½ m.p.h.	51 tons
900	Bo-Bo	515	47,000 lb. at 1¼ m.p.h.	72 tons

★ ★ ★

25 KV CONCENTRIC OIL-FILLED CABLE

The forthcoming electrification of the London Midland section of British Railways between Crewe and Manchester on the 25 kV single phase 50 cycle system will necessitate power being drawn from the Central Electricity Authority's 132 kV network at various supply points. Among these will be a trackside-substation at Heaton Norris, which will be connected to the Authority's 132 kV substation at Stockport, a distance of four miles. The cable necessary for this purpose is to be manufactured by W. T. Henley's Telegraph Works Company, Limited, 51/53 Hatton-garden, London, E.C.1, and will be of the concentric paper-insulated oil-filled type with a combined pilot and telephone cable. It is of a new design, which has been developed in the research laboratories of the firm, especially for railway electrification work.

★ ★ ★

ELECTRO-MAGNETIC CLUTCH

The range of Autronic products is now to be made and distributed by Newport Instruments (Scientific and Mobile) Limited, Newport Pagnell, Buckinghamshire. The clutches range in size from 1 in. in diameter upwards, and operate at 12 or 24 volts. The 1 in. diameter version will transmit 30 in.-lb. at a loading of 0·35 amperes and the 3¼ in. diameter version will transmit 210 in.-lb. at 0·9 amperes. The magnet and armature are of alloy steel with their opposing faces highly polished and hardened. The separating plate is made of soft iron alloy with high magnetic permeability. Current control can be designed to suit different applications, and may vary from a simple variable resistance to one following a log. law. Smaller sizes may be run dry, but the larger models are totally enclosed in an oil bath.

ATOMIC REVIEW

Swedish Survey

EARLY this year we began a series of articles on the nuclear energy programmes adopted by various countries. This week the series continues with an account of atomic energy work in Sweden.

Programme

As one of the smaller countries with no interests in armaments and abundant supplies of water power, Sweden could be the last to concern herself with the development of nuclear energy. Yet, by 1963, she plans to have a 100 MW atomic power station in commission and a full programme thereafter. Her allocation of Kr. 530 million (about £37 million) over the next five years shows that she means to be fully prepared to take part in any major industrial advance that nuclear engineering may bring about. Marine propulsion is one of the most obvious fields in which Swedish industry cannot afford to lose touch with developments.

The State Power Board has organised a department of atomic energy and plans a heating station, called Adam, of about 75 MW heat for the city of Västerås. This station is scheduled to be in operation in 1960 and will probably be constructed and built by the Atomic Energy Company, the State Power Board and Asea in co-operation. The Board also plans an atomic power plant, called Eva, scheduled to be ready in 1963.

Energy Needs

The president of the Swedish State Power Board, Mr. Ake Rusck, made an analysis of the reasons which prompted his organisation to go ahead with atomic power stations. Basically it is the realisation that the reserves of water power will not last for ever. Sweden has a potential annual output of hydro-electric power estimated at some 80,000 million kWh; some 24,000 million kWh is currently being produced and demand for electricity is rising at the rate of 6½ per cent. per annum. The reserves are thus sufficient for about 20 years expansion. All the more fortunate, according to Mr. Rusck, that " the fundamental principles for the exploitation of atomic power have been discovered before we have reached the situation where all our water-power resources are fully utilised. It is possible even now to foresee that within the next 20 years sufficient progress should have been made in adapting and applying these scientific discoveries to enable sufficiently reliable and economical atomic power stations to be built."

This emphasis on costs is understandable enough: Swedish industry currently enjoys electric power for about half the price obtaining in this country, or any other where steam-generated power is the main source of energy. To surrender this advantage could have serious repercussions on industry's competitive ability in export markets.

Atomic Space Heating

Although Sweden is well supplied with cheap electricity, there is an almost complete absence of indigenous resources of coal, oil, and natural gas, and over 70 per cent. of the country's total energy requirements has to be imported, most of it in the form of fossil fuels. A considerable part of this is used for space heating. There are, on the other hand, considerable reserves of uranium and the case for exploiting these is a strong one. This was stated most emphatically in two reports published last year on the subject of Sweden's energy problems. The Fuel Committee of 1951, made a thorough study of the fuel and power situation and outlined the main lines of a policy for active work in this field. the *ad hoc* Atomic Energy Commission studied the problems connected with the utilisation of atomic energy and made recommendations on ways in which development work in the atomic field could be organised and allocated. Both reports were unanimous concerning the importance to Sweden of a rapid development of this new source of energy. In the words of the Fuel Committee, " Our alum shale deposits with their content of uranium is the only domestic energy resource now available that will suffice for our constantly growing need. Consequently, the solution of the fuel problem first of all presupposes that the active energy policy is focused on a rapid exploitation of atomic energy." Space heating was one of the applications chosen since the low temperature heat available from early reactors is admirable for this purpose.

Adam

As a consequence of her special needs, Sweden will make space heating her first nuclear project. The atomic reactor Adam will supply a thermal output of about 75 MW to a district heating plant near Västerås. Adam, which is due to be commissioned in 1960, will be followed quickly by a sister plant to be erected in the suburbs of Stockholm. After 1960, one such reactor per year will be built for district heating schemes. A model of Adam, which will probably use natural uranium fuel and be moderated by heavy water, is shown in Fig. 1.

Adam's Rib

The State Power Board, who decided to start with a district heating plant in order to gain experience under relatively simple conditions, have planned their first steam power station, named Eva, to be operating less than three years (1963) after Adam is commissioned. A model of Eva appears in Fig. 2. It has not yet been finally decided what type of reactor will be used but there is good evidence that natural uranium with heavy water as a moderator will be initially adopted. The reason for this choice was recently given by Mr. Harry Brynielsson, the managing director of S. B. Atomenergi, as the very low grade quality of the raw material available locally. This makes the price for uranium comparatively high, and therefore " the system of natural uranium and heavy water which requires limited quantities of uranium investment, looks especially attractive to us."

Experimental Reactors

The first experimental reactor, R1, was started up in July, 1954. It has about 3 tons of natural uranium metal rods, canned in aluminium tubes and suspended in an aluminium tank

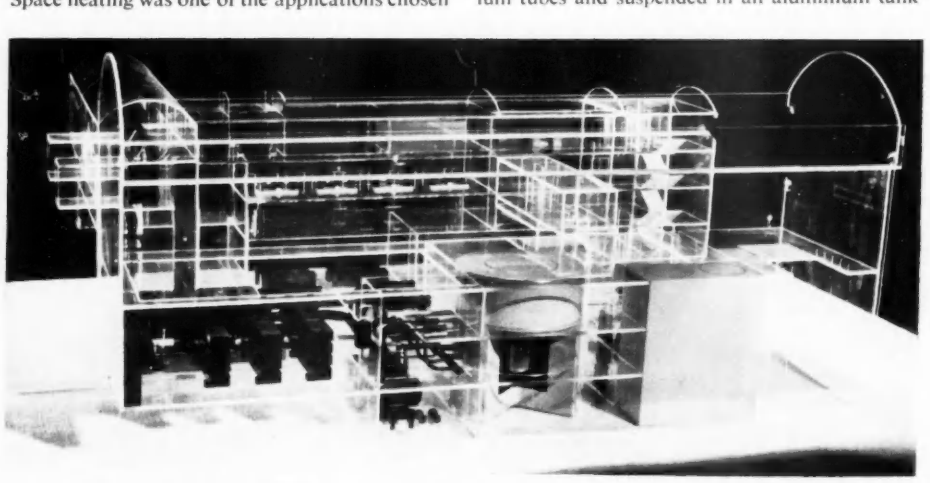


Fig. 1 Model of Adam, a reactor project designed to supply 75 MW energy for space heating. Due to be commissioned in 1960, it will be located near Västerås, Sweden.

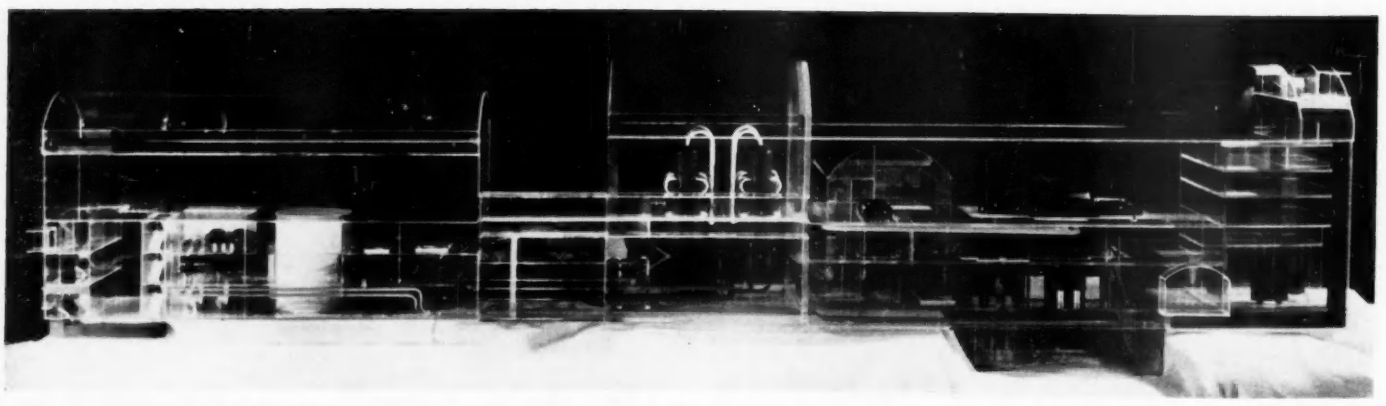


Fig. 2 Model of Eva, a nuclear power station of 100 MW electrical capacity to be built in Sweden by 1963. Natural uranium will serve as fuel.

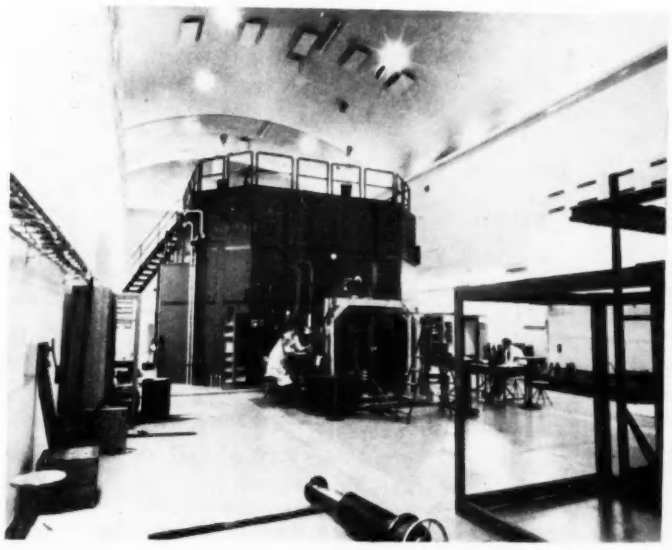


Fig. 3 Reactor hall of Sweden's first experimental reactor (R1). Moderated by heavy water and using natural uranium fuel, it has a design power of 300 kW, though it has operated at 600 kW.

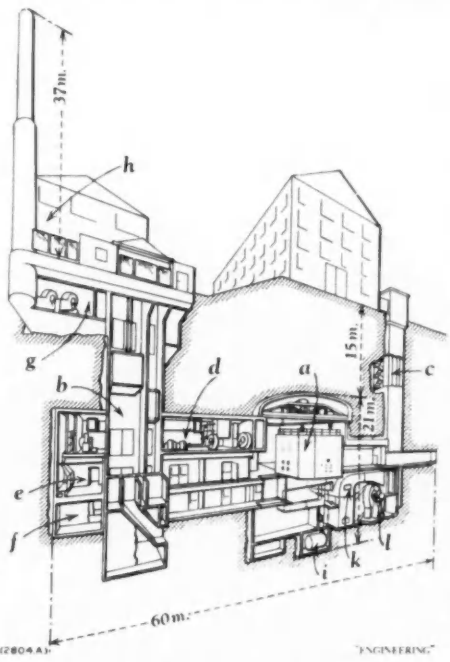


Fig. 4 Arrangement of Sweden's first experimental reactor, R1, situated underground.

containing about 5 tons of heavy-water moderator, obtained from Norway. The design power level is 300 kW, but it has been run continuously at 600 kW. The possibility of using enriched material in some of the rods to obtain higher neutron flux is being investigated. The reactor has one large vertical experimental channel passing through it, and many other channels and facilities for carrying out irradiations and experiments. The reactor hall, which is situated underground in a fairly populous part of Stockholm, is illustrated in Fig. 3, and diagrams showing the layout of the plant can be seen in Figs. 4 and 5. A model of the installation, which was described fully in ENGINEERING, vol. 179, page 462, 1955, appears in Fig. 6.

Besides this reactor, exponential experiments are also carried out in an assembly called ZEBRA (Zero Energy Bare Reactor Assembly). These experiments are performed in collaboration with the Dutch-Norwegian organisation JENER, and the results have proved so important that a permanent installation has been planned for both exponential experiments and criticality tests at a new Swedish research centre at Studsvik. The site is situated about 80 miles south of Stockholm on the Baltic coast.

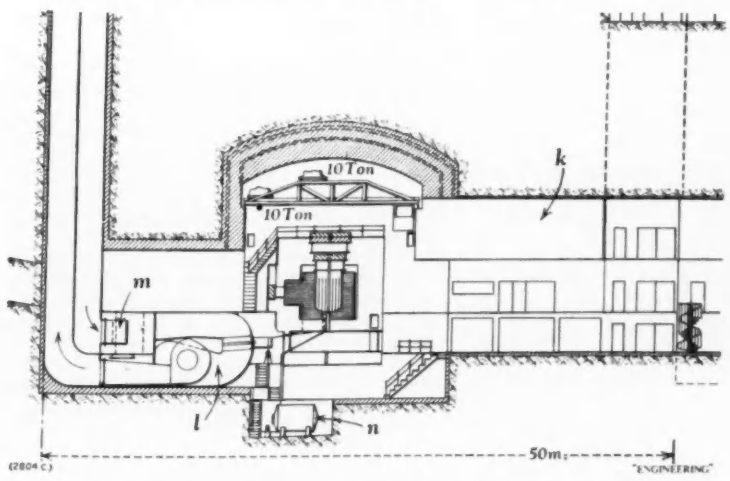
Mr. Brynielsson announced that Sweden was to import 25 tons of heavy water from the United States and that his company had ordered a reactor for research and materials testing from American Car and Foundry Industries Incorporated. Contrary to the Swedish practice so far, this reactor will use enriched uranium and ordinary water. It is scheduled to go into operation at the end of 1958. This reactor, R2, will have a power of 30 MW and a neutron flux of 10^{14} neutrons per sq. cm. per sec. Several laboratories for different purposes will also be erected at Studsvik. For example, a van de Graaff machine of 3 MeV has been purchased from the High Voltage Engineering Company. This will be used mainly for the study of fast neutrons. A plutonium separation plant on a laboratory scale is already running in Stockholm and at Studsvik a plant will be built for carrying out separation on an industrial scale.

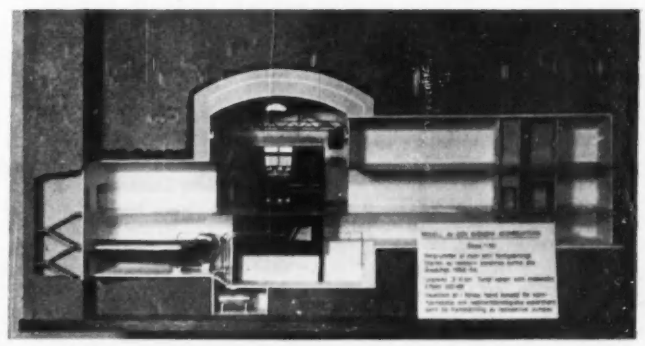
During the last year, the design of industrial reactors based upon natural uranium and heavy water has been started within the Swedish Atomic Energy Company (S.B. Atomenergi). Since local raw material for uranium production is very low-grade, thus making the Swedish price for uranium comparatively high, the system of natural uranium and heavy water which requires limited quantities of uranium investment, looks especially attractive. The main work has been carried out for a reactor, called R3a, with 76 MW heat output, for district heating. This is sufficient for a city of 30,000 inhabitants. As a temperature of only slightly above 100 deg. C. is required for the heating water, the problems are less severe. The reactor is designed in such a way that it can later be used also for the production of 14 MW of electricity by back pressure turbines. The later version of the reactor is called R3b. The coolant header of the reactor will be designed for a pressure of 900 lb. per sq. in., but the reactor may be used first only for the production of hot water at about 100 deg. C., using fuel elements canned with aluminium. Later, the fuel elements can be replaced by others, canned, for example, with Zircaloy, and it will then be possible to raise the temperature to 256 deg. C. and generate steam for the back pressure turbines. Fuel elements of sintered uranium oxide will be used. (If the production of fuel elements with Zircaloy can be solved in time, the company will proceed directly to the reactor R3b.) This reactor will be built in collaboration with the city of Stockholm for a suburb, Farsta, south of the city, and is scheduled to go into operation in 1960. It will be located in an underground building.

This reactor will provide valuable information for subsequent projects, for example, steam producing reactors for the pulp and paper industry, and also a reactor, R4, which is a power reactor of about 100 MW electrical capacity using natural uranium and heavy water. Studies indicate that this combination is interesting from the economic point of view, taking into account the prices paid in Sweden for oil and coal. Other types of reactor are also being studied in the company, but no definite proposals are ready. It is also expected that a nuclear propelled ship will be built in Sweden during the next few years.

Atomic Energy Industry

The Swedish Government were quick to seize on the significance that the development of atomic energy could have for a country so starved of fossil fuels and so richly endowed with uranium. As early as 1945, they appointed an Atomic Energy Committee to follow the developments in this field. The committee now function as a research council, supporting different kinds of fundamental research in the field of nuclear engineering at universities and other institutions. In 1946, the Committee proposed the formation of a special organisation to undertake industrial projects connected with atomic energy develop-





Key for Figs. 4 and 5

a reactor
b and *c* shafts
d chamber for ventilation plant
e active-chemical laboratory
f bank for radioactive samples
g storage rooms for radio-active waste
h chemical laboratory for the extraction of plutonium and fission products
i storage tank for heavy water
k ventilation machinery
l ventilator for heavy water to air heat exchanger
m filter for cooling air
n storage tank for heavy water

Figs. 5 and 6 The layout of the experimental reactor R1 and its ancillary plant are shown in Fig. 5 (left), and a model of the installation in Fig. 6 (right).

Fig. 7 Uranium is found in Swedish alum shale deposits and an extraction plant was built at Kvarntorp in 1953. Further plants are also planned.

ment. Some Swedish manufacturing concerns had already shown interest in such projects and the new organisation, S.B. Atomenergi, with a share capital (now Sw. Kr. 14 million) owned jointly by the State with four-sevenths of the total and by private industrial interests—about 70 of the larger companies—who hold the remainder. This form of company was chosen because, according to Mr. Brynielsson, "this type of enterprise had by tradition proved to be efficient in the realisation of industrial operation."

Uranium Production

S.B. Atomenergi are concerned with all uranium production in Sweden. They run a small plant in co-operation with the Swedish Shale Oil Company for the extraction of uranium from oil shale (uranium content ranges from 200 gram per metric ton to 300 gram) with a capacity of about 5 tons per year. The plant capacity is shortly to be doubled and then further increased. Fig. 7 shows the plant, which is situated near Kvarntorp, as it is at present. The uranium is extracted by leaching the ground ore with a solution of sulphuric acid which percolates through the material contained in large vats lined with acid-proof stone. From the pregnant solution the uranium is precipitated as a phosphate. A new installation using ion exchangers will, however, be installed.

The technical concentrate contains 20 to 30 per cent. of uranium—about a thousand times more than the shale. This concentrate is purified in a chemical plant in Stockholm to uranium trioxide of nuclear purity. The trioxide is reduced with hydrogen and converted to fluoride with gaseous hydrogen fluoride in rotating furnaces and the uranium tetrafluoride reduced to metal with calcium. The metal ingot is then recast in a vacuum furnace and the billets are rolled or extruded to desired dimensions.

The Atomenergi company estimate Sweden's total needs of uranium at 20 metric tons a year in 1960 rising to 75 metric tons in 1965 and some 200 tons a year after 1970. A considerable amount of research is being carried out by the company on the many problems concerning fuel elements, such as the structure of the metal, cladding, the use of sintered uranium oxide, corrosion tests, and other topics.

New Refining Plant

Plans are being made to build a 100 ton uranium refining plant in the Billingen Hills, t o be in producton by the early sixties. A plant of this kind would consume 2,000 tons of shale daily and be the third largest in Europe.

Private Enterprise

The bulk of the co-operation so far has taken place between S.B. Atomenergi, the State Power Board and Asea who are the leading manufacturers of electrical machinery in Scandinavia. These three organisations are co-operating in the development and construction of Adam and Eva, the first two reactor projects to have been approved. But as the State Power Board produce only about 40 per cent. of the electricity output of the country, there is an important private industry and some of the largest producers have organised a study group under the name of Atomkraftkonsortiet Krangede and Company, to keep in touch with developments but have announced no definite plan for a power station.

A technical assistance agreement for close co-operation on nuclear energy projects was signed in May between Asea and Atomics International, a division of North American Aviation, Incorporated. Atomics International have been engaged in the development of peace-time applications of atomic energy for over 10 years and there is little doubt that Asea will greatly benefit by this association. The agreement contemplates mutual assistance between the two companies in the design, construction and installation of nuclear reactors for the generation of power and for general research and development in the nuclear field. Atomenergi also have a "bilateral" agreement with the United States and a "close and very valuable contact" with many other countries in Europe and elsewhere.

Nuclear Physics Co-operation

The Northern Council of Scandinavian countries—Sweden, Norway, Finland and Denmark—have formed a Scandinavian institute for the study of nuclear physics in Copenhagen and have agreed to co-operate in the setting up of a permanent organisation on atomic questions. Part of their brief will be to keep in touch with international developments.

Cost of Programme

Opinion varies widely over the speed at which nuclear power stations will take over from hydro-electric stations. Writing in the November issue of *The Anglo-Swedish Review*, Mr. Ingvar Wivstad boldly stated that "as far as Sweden is concerned, we must reckon with nuclear power in future taking over the role at present played by water power in our power supply system." But this is taking a very long term view, when the whole of the water resources has been taken up (that is in 20 years' time). Until costs are comparable—and this may never happen—Sweden is highly unlikely to force the pace and will in all probability concentrate on district heating over the next 10 to 20 years. It is possible, however, that pressure from public opinion may force the Government's hand in the other direction. In the article quoted above, Mr. Rusck of the Swedish State Power Board mentions that "certain interests, which have the preservation of nature at heart, have said that power companies should limit or even stop the building of hydro-electric stations and should build atomic power stations instead." Mr. Rusck's reply is that by no stretch of the imagination could Sweden produce enough reactors to replace the 400 MW by which the hydro-electric supply increases a year with power from atomic stations. In Sweden, as elsewhere, the production of electricity from nuclear power must remain for several decades only a small proportion of the amount consumed.

It was announced last month that Sweden was to consider a special tax on existing sources of energy to finance the atomic energy programme and also the considerable expansion of hydro-electricity output. The new tax is estimated to yield Kr. 525 per annum (£36 million) of which about 30 per cent. will be borne by transport, 23 per cent. by industry and the rest by other consumers.

Unarmed Combat

The far-sightedness of Sweden's responsible leaders in starting to prepare for the atomic age immediately after the war is a sure sign of industrial liveliness and enterprise. Unencumbered by considerations of armaments it will not be many years before the Swedes, and particularly Asea, are in a position to compete for nuclear engineering contracts in export markets, thus disproving the popular belief that progress in this field can only be made on the back of a large armament budget.

Glandless Pumps

Hayward Tyler and Company, Limited, of Luton, have received an order from A.B. De Lavals Angturbin of Sweden for six glandless pump and motor units for installation in Sweden's first power reactor. This order, placed on behalf of Swedish Atomenergi, includes four 250 h.p. units and two 60 h.p. units, all in stainless steel. The larger pumps will handle the main circulation of heavy water through the reactor core; the smaller ones will handle the heavy-water moderator. The total value of the contract is in the region of £50,000. Hayward Tyler have already supplied a number of glandless heavy-water pumps to the U.K.A.E.A. for installation at Harwell, Dounreay, and in Australia.

Misunderstanding

Speaking at the annual luncheon of the British Electrical and Allied Industries Research Association (E.R.A.), Sir Christopher Hinton said that prior to his recent visit to Sweden he had been asked his views on the Swedish atomic energy programme. He had replied that it appeared excellent since the Swedish authorities planned to use atomic energy for space heating, and the low-temperature heat at present available from nuclear sources would be ideal for that purpose. He later remarked that engineers were generally unsympathetic towards low-grade heat. Unfortunately the conjunction of these two remarks led to a misunderstanding, and he was quoted the following day in the Swedish papers as condemning the Swedish atomic power programme. Though this was by no means his intention; it should nevertheless be borne in mind that to-day's nuclear reactors represent a passing phase, and that when reactors producing high-quality heat are available, the economics of reactor usage will have to be reconsidered.

EFFORTLESS RAIL-CAR DRIVING

Automatic Gear Changing

One of the problems caused by the introduction of large numbers of Diesel rail cars on British Railways, is that of training drivers. Steam locomotive men have been, and are being, trained very successfully for the new duties, but the training takes time, and means of shortening the training period are worth investigating. Simplification of driving is a help, and on a Diesel rail car set recently put into service by British Railways, the work of the driver has been eased considerably by the fact that gear changing is completely automatic. The rail car set consists of a power car and a driving trailer of the familiar British Railways type, the power car having two A.E.C. horizontal six-cylinder engines, each developing 150 b.h.p. at 1,800 r.p.m.

Drive from each engine is taken through a fluid coupling and a Wilson 4 speed epicyclic power-shift gearbox, made by Self-Changing Gears, Limited, Lythalls Lane, Coventry, who also designed and made the automatic gear-changing equipment. The automatic gear is superimposed on the standard gearbox, and an existing car could be modified quite easily. Cars equipped with automatic gear-changing control can be marshalled into trains of similar vehicles fitted with manual gear control, provided that an automatic control car heads the train; alternatively, the automatic car or cars can be put under the control of a manual driving car by switching off the automatic control gear. In addition to its obvious advantages in simplifying driving, the automatic gear-change equipment gives promise of fuel economy, since it is impossible for the vehicle to be overdriven in the wrong gear.

The standard Wilson gearbox, as is well known, has pneumatically operated band brakes, which bring into commission the appropriate epicyclic gear trains according to the ratio required. Selection of the ratio, by manual control, is effected by a hand lever, a multi-position switch, and electrically-operated air valves. On the automatic version of the gear the electrically-operated valves are brought under the control of relays which are energised according to the vehicle speed. The relays are grouped in a small control box, which can be mounted in any convenient position; the driver's cab is an obvious choice of position.

The manual gear selection handle is replaced by a simple two-position control, marked " N " (neutral) and " D " (drive). Engagement of reverse gear is by means of a separate handle, which also controls the master switch, to make the complete control gear inoperative. Provision can be made, if required, for a third position for the drive-control handle. In this position it varies the gear-change characteristics as required; for example, it could prevent the gear mechanism from changing up, while leaving it to change down normally if necessary.

All the driver has to do to start the train is to set the control handle to " D," release the brakes, and accelerate. First gear is engaged automatically, and as soon as the train speed reaches a pre-set figure, the appropriate relays operate for a change to second gear, and so on until top gear is in use. A fall in speed due to a gradient against the train, or because the driver has checked it and then wants to speed up again, is the signal for the appropriate lower gear to be engaged automatically.

Control of the gear-changing mechanism from train speed is exercised through two small direct-current generators driven by the two gearboxes, and giving a voltage signal, varying with the speed, to the relays. These control the air valves accordingly. The generators usually work at 24 volts, but this can be varied according to requirements. Two generators are used as a safety measure. Either is fully capable of taking over the whole of the control work, and in the event of failure of one of the generators the train could continue in service. In fact, the only intimation the driver would have of the failure would be from the warning light on the relay panel. This would show that one of the generators had ceased to operate, and would therefore warn the driver that the vehicle required servicing as soon as possible. Meanwhile, its operation would continue unimpaired.

Two-position drive-control handle for Wilson four-speed epicyclic gearbox.

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NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

MANCHESTER
" Exhibitions and Displays," by D. V. Durling. Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., July 3, 7 p.m.

Institution of Electronics

LONDON
" Theoretical Problems of Television Astronomy," by Dr. P. B. Fellgett; and " The 1956 Opposition of Mars," by B. V. Somes-Charlton (with films). Beveridge Hall, Senate House, University of London, W.C.1. Fri., July 5, 6 p.m. (Tickets required.)

Physical Society

SOUTHAMPTON
OPTICAL GROUP Summer Meeting, Mon. and Tues., July 8 and 9.
Opening Address, by Professor A. M. Taylor; " Devices for the Measurement of Optical Phase Differences," by H. G. Jerrard; and " On Spectrophotometric Measurements of Free Radicals Produced Photochemically," by Dr. M. C. K. Symons, at 2 p.m. " The Photoelectric Recording of Interference Fringes," by Dr. E. V. Vernon; " Measurements of the Faraday Magneto-Optical Rotation," by Professor A. M. Taylor; and " Problems of Measuring Phase and Size Simultaneously in a Microscope," by Professor E. Ingelstam, at 4.15 p.m. The University, Southampton. Mon., July 8.
" Artificial Birefringence in Solids," by Dr. J. E. Braybon; " The Theory and Techniques of Micro-Wave Spectroscopy as Compared with Those in the Visible Region," by Dr. J. E. Ingram; " Birefringence in Flowing Liquids," by H. G. Jerrard; and " On Tilton's Vitron Theory of the Structure of Glass," by Dr. W. S. Rodney, at 9.30 a.m. " Precision Measurements of Refractive Index by Means of a Birefringent Shearing Interferometer," by Professor E. Ingelstam, at 2 p.m. The University, Southampton. Tues., July 9.

Plastics Institute

LONDON
Annual General Meeting. Gallery Conference Room, National Hall, Olympia, W.14. Fri., July 19, 12 noon.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Institution of Electronics, 78 Shaw-road, Rochdale, Lancs.
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Plastics Institute, 6 Mandeville-place, London, W.1. WELbeck 5439.)

PNEUMATIC HOIST

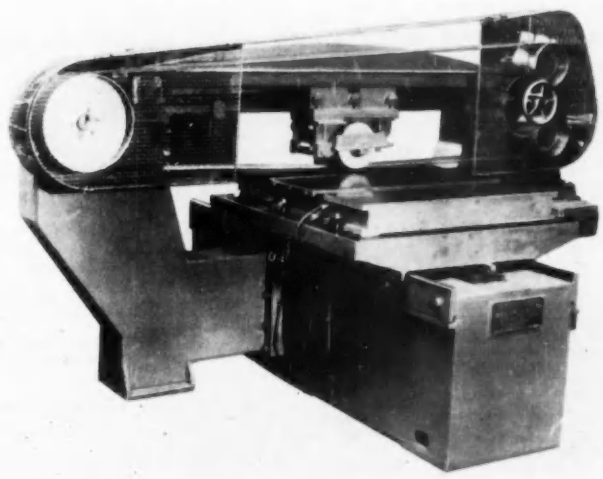
An advantage of a pneumatic hoist is that very low creep speeds are available enabling accurate positioning of heavy parts, and since also air-powered equipment is unaffected by salt laden atmosphere, they are being used extensively for marine purposes. Such a hoist, made by Atlas Copco (Great Britain) Limited, Beresford-avenue, Wembley, Middlesex, with a capacity of five tons, has been installed in the engine room of the motor tanker Ferncrest, 34,800 tons, to assist in engine overhauls. The hoist has a speed of 13 ft. per minute to a maximum height of 23 ft., using a wire of 0·63 in.

ABRASIVE FINISHING OF LARGE FLAT SURFACES

Surface finishing of metal, plastic or wood can be carried out on an abrasive belt machine introduced by Taylor Tools and Supplies, Limited, Atlantic-street, Broadheath, Altrincham, Cheshire.

It uses abrasive-coated paper belts, which are mounted so that a contact roller or pad, bearing on the back of the belt, presses the abrasive face into contact with the work. The contact roller is supported by a rigid bridge and traversed by an air-hydraulic mechanism, so giving cross-traverse to the abrasive action. Longitudinal traverse is provided by the movement of the table on the machine bed, and the whole of the table surface, which is 36 in. square, can be covered. Work longer than 36 in. can be dealt with by moving it along the table and re-clamping. Traverse speeds and contact pressures can be adjusted to suit the material being processed and the finish required.

As illustrated, the machine is equipped with electro-magnetic clamping for holding the work, but other securing methods are available when required.



Traverse of the table and of the contact roller behind the abrasive belt enable this flat-surface finishing machine to deal with an area of 36 in. by 36 in.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *April* 26, *page* 542; *or May* 31, *page* 702. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Occupational Health, Twelfth International Congress on.—Mon., July 1, to Sat., July 6, at Helsinki. Apply to the secretary, organising committee, Haartmaninkatu, 1, Helsinki, Finland.

Atomic Energy Exhibition, International.—Mon., July 1, to Mon., Sept. 16, at Schiphol Airport, near Amsterdam, Holland. Organised with the support of the Dutch Government, the Amsterdam City Council, and the Amsterdam Chamber of Commerce. Secretariat offices: 37 Roemer Visscherstraat, Amsterdam. *Agents:* Galitzine and Partners Ltd., 17 Victoria-street, London, S.W.1. Tel. ABBey 4013.

Royal Agricultural Show.—Tues., July 2, to Fri., July 5, at Costessey, Norwich. Organised by the Royal Agricultural Society of England, 35 Belgrave-square, London, S.W.1. Tel. BELgravia 5323.

Physical Problems of Colour Television, International Symposium.—Tues., July 2, to Sat., July 6, in Paris. Organised by the International Union of Pure and Applied Physics, the Société Française des Radioélectriciens and the Société Française des Ingénieurs et Techniciens du Vide. Apply to the secretary, Colloque International sur les Problèmes de la Télévision en Couleurs, Conservatoire National des Arts et Métiers, 292 Rue Saint-Martin, Paris, 3e.

Calgary Exhibition and Stampede.—Sat., July 6, to Sat., July 13, at Calgary, Alberta. General trade fair organised by Calgary Exhibition and Stampede Ltd., Administrative Building, Exhibition Grounds, Calgary, Alberta, Canada.

***Building Exhibition.**—Sat., July 6, to Sat., July 13, at the South-West Essex Technical College and School of Art, Forest-road, Walthamstow, London, E.17. Tel. LARkswood 2272.

Lamp Show.—Sun., July 7, to Fri., July 12, in New York. Exhibition of electrical and radio apparatus. Communications to Mr. George F. Little, 220 Fifth-avenue, New York 1, U.S.A.

Solvent Effects and Reaction Mechanism, Symposium.—Mon. and Tues., July 8 and 9, in the Queen's Building, Queen Mary College, London, E.1. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Northern Rhodesia Industrial and Commercial Show.—Mon., July 8, to Sat., July 13, at Ndola. Organised by the Northern Rhodesia Industrial and Commercial Show Society, Ltd., P.O. Box 646, Ndola, Rhodesia.

Navigation Congress, 19th International.—Mon., July 8, to Sat., July 20, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Sponsored by the Permanent International Association of Navigation Congresses. Apply to Mr. A. C. Morrison, secretary, British Organising Committee, at the Ministry of Transport and Civil Aviation, Berkeley Square House, London, W.1. Tel. MAYfair 9494.

Institution of Naval Architects, Summer Meeting.—Tues., July 9, to Thurs., July 11, in Bristol. Organised by the Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. Tel. SLOane 4622.

Great Yorkshire Agricultural Show.—Tues., July 9, to Thurs., July 11, at Harrogate. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

***Institution of Mechanical Engineers, Summer Meeting.**—Tues., July 9, to Fri., July 12, at Cambridge. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

***Thermodynamic and Transport Properties of Fluids, Conference.**—Wed., July 10, to Fri., July 12, at the Institution of Mechanical Engineers, London. Organised jointly by the International Union of Pure and Applied Chemistry; and the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

British Plastics Exhibition and Convention.—Wed., July 10, to Sat., July 20, at Olympia, London, W.14. Apply to British Plastics Exhibition, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

***Institution of Mechanical Engineers, Automobile Division, Summer Gathering.**—Thurs., July 11, in Luton. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

Recent Advances in the Chemistry of Terpenoid Compounds, Symposium.—Thurs. and Fri., July 11 and 12, in the Chemistry Department, The University, Glasgow. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Materials for Nuclear Engineering. Conference.—Thurs. and Fri., July 11 and 12, at works of the Associated Electrical Industries Ltd., Aldermaston, Berks. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Electronics Exhibition and Convention, 12th Annual.—Thurs., July 11, to Sat., July 13, and Mon., July 15, to Wed., July 17, at the College of Science and Technology, Manchester. Organised by the Northern Division of the Institution of Electronics, 20 Buckingham-street, London, W.C.2. Apply to Mr. W. Birtwistle, 78 Shaw-road, Thornham, Rochdale, Lancs. Tel. Oldham Main 6661.

***Careers for Girls in Engineering, Conference.**—Sat. and Sun., July 13 and 14, at the City of Coventry Training College. Organised by the Women's Engineering Society. Conference headquarters: 26 Victoria-street, London, S.W.1. Tel. ABBey 5481. See also page 805.

Building Plant Exhibition.—Mon., July 15, to Sat., July 20, at Heaton Park, Manchester. Organised by the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611.

Edmonton Exhibition.—Mon., July 15, to Sat., July 20, at Edmonton, Alberta. Organised by the Edmonton Exhibition Association, Ltd., Exhibition Grounds, Alberta, Canada.

Nuclear Physics Conference.—Wed. and Thurs., July 17 and 18, in the Physical Laboratories, The University, Manchester. Organised by Professor S. Devons, F.R.S., under the auspices of the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***High Altitude and Satellite Rockets Symposium.**—Thurs., July 18, to Sat., July 20, at the College of Aeronautics, Cranfield, Bletchley, Bucks. Organised jointly by the British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (Tel. TATe Gallery 9371); and the Royal Aeronautical Society, 4 Hamilton-place, London, W.1. Tel. GROsvenor 3515.

Sydney Industries Fair.—Mon., July 22, to Sat., Aug. 3, at the Sydney Showgrounds, Sydney. Apply to the Industrial Public Relations Service of Australia, R.A.S. Showground, Box 5063, G.P.O., Sydney.

Royal Welsh Show.—Wed., July 24, to Fri., July 26, at Aberystwyth. Organised by the Royal Welsh Agricultural Society, Queen's-road, Aberystwyth. Tel. Aberystwyth 7551.

Skane (Swedish National) Fair, 39th.—Sat., July 27, to Sun., Aug. 4, at Malmo. Organised by the Skanemassan Kommissariat, Stora Nygatan 15, Malmo, Sweden.

Dornbirn International Export and Trade Fair.—Fri., Aug. 2, to Sun., Aug. 11, at Dornbirn, Austria. Apply to the Export & Mustermesse Gesellschaft m.b.H., Dornbirn, Austria; or to the British-Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

"Model Engineer" Exhibition.—Wed., Aug. 21, to Sat., Aug. 31, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Organised by *The Model Engineer* (Percival Marshall & Co. Ltd.), 19-20 Noel-street, London, W.1. Tel. GERrard 8811.

***Gas Chromatography, National Conference.**—Wed., Aug. 28, to Fri., Aug. 30, at Michigan State University, East Lansing, Mich., U.S.A. Organised by the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

Radio Show (24th Annual National Radio and Television Exhibition).—Wed., Aug. 28, to Sat., Sept. 7, at Earl's Court, London, S.W.5. Preview for overseas and special guests, Tues., Aug. 27. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

St. Erik's Fair, 15th International.—Sat., Aug. 31, to Sun., Sept. 15, in Stockholm. Apply to the manager, St. Erik's Fair, Stockholm 28.

Frankfurt International Fairs.—*Autumn Fair:* Sun., Sept. 1, to Thurs., Sept. 5, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

Leipzig International Fairs.—*Autumn Fair:* Sun., Sept. 1, to Sun., Sept. 8, at Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

Sanitary Installation and Heating Technique Exhibition.—Sun., Sept. 1, to Sun., Sept. 8, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.h.H. (NOWEA) Ehrenhof 4, Düsseldorf, Germany.

International Union of Geodesy and Geophysics, 11th General Assembly.—Tues., Sept. 3, to Sat., Sept. 14, in Toronto. Held under the auspices of the International Union of Geodesy and Geophysics, 30 Avenue Rapp, Paris, 7e. Apply to the secretary of the Arrangements Committee for Canada: Professor J. A. Jacobs, Geophysics Laboratory, University of Toronto, Toronto 5, Ontario, Canada.

British Association Meeting.—Wed., Sept. 4, to Wed., Sept. 11, in Dublin. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109. See also page 805.

Cologne Fairs.—*Autumn Fair: Hardware and Household Goods:* Sat., Sept. 7, to Mon., Sept. 9; and *Clothing and Textiles:* Sun., Sept. 15, to Tues., Sept. 17, at Cologne. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Vienna International Fairs.—*Autumn Fair:* Sun., Sept. 8, to Sun., Sept. 15, in Vienna. *Agents:* British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

Commonwealth Mining and Metallurgical Congress, Sixth.—Sun., Sept. 8, to Wed., Oct. 9, at Vancouver, British Columbia, and other centres in Canada. Apply to the congress secretary, 507 Metropolitan Building, 837 West Hastings-street, Vancouver 1, B.C., Canada.

***Instrument-Automation Conference and Exhibit, 12th Annual.**—Mon., Sept. 9, to Fri., Sept. 13, in the Cleveland Auditorium, Cleveland, Ohio, U.S.A. Organised by the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

Marseilles International Fair, 33rd.—Sat., Sept. 14, to Mon., Sept. 30, at Marseilles, France. *Agents:* Butler's Advertising Service, 22 St. Giles High-street, London, W.C.2. Tel. TEMple Bar 8905.

***Royal Aeronautical Society's Garden Party.**—Sun., Sept. 15, at Wisley Aerodrome, near Weybridge, Surrey. Organised by the Royal Aeronautical Society, 4 Hamilton-place, London, W.1. Tel. GROsvenor 3515.

European Machine Tool Exhibition.—Sun., Sept. 15, to Tues., Sept. 24, at Hanover. Applications for space may be made to the Machine Tool Trades Association, Brettenham House, Lancaster-place, London, W.C.2. (Tel. TEMple Bar 3606). Other inquiries should be sent to Schenkers Ltd., 13 Finsbury-square, London, E.C.3. Tel. METropolitan 9711.

Institute of Metals Autumn Meeting.—Tues., Sept. 17, to Fri., Sept. 20, in Glasgow. Apply to the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Handicrafts, Homecrafts and Hobbies Exhibition, Fifth International.—Thurs., Sept. 19, to Sat., Sept. 28, at Earl's Court, London, S.W.5. Apply to the exhibition's organiser, 24 Store-street, London, W.C.1. Tel. MUSeum 9792.

Motor Exhibition, International.—Thurs., Sept. 19, to Sun., Sept. 29, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Automatic Measurement of Quality in Process Plants.**—Mon., Sept. 23, to Thurs., Sept. 26, at University College, Swansea. Organised by the Society of Instrument Technology, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251. See ENGINEERING, May 31, page 682.

Fisheries Trade Fair, Second International.—Fri., Sept. 27, to Sun., Oct. 6, in the Exhibition Hall Forum, Copenhagen, Denmark. *Agents:* John E. Buck & Co., 47 Brewer-street, Piccadilly, London, W.1. Tel. GERrard 7576.

German Brewery and International Beverage and Catering Equipment Exhibition.—Sat., Sept. 28, to Thurs., Oct. 10, in Munich. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Brewers' and Allied Traders' Exhibition.—Mon., Sept. 30, to Fri., Oct. 4, at Olympia, London, W.14. Organised by Trades, Markets and Exhibitions Ltd., 623 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 1371.

Fishing Gear, International Congress on.—In October, at Hamburg, Germany. Organised by the Food and Agriculture Organization of the United Nations, Viale delle Terme de Caracalla, Rome. See ENGINEERING, July 13, 1956, page 38.

***Plasma and Atomic Physics, Conference.**—Thurs. and Fri., Oct. 3 and 4, at the Atomic Energy Research Establishment, Harwell. Apply to the secretary, the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Book Fair, Ninth International.—Sat., Oct. 5, to Thurs., Oct. 10, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

Welding Exhibition "Lastu 57."—Sat., Oct. 5, to Sat., Oct. 12, in the "Margriethal," Utrecht, Holland. During the exhibition a two-day symposium on **The Metallurgy of the Welding of Steel** will be held. Organised by Nederlandse Vereniging voor Lastechniek, 62, Zeestraat, The Hague, Holland.

Electronics Conference Exhibit, National.—Mon., Oct. 7, to Wed., Oct. 9, in the Hotel Sherman, Chicago. Organised by the National Electronics Conference, Inc., 84 East Randolph-street, Chicago 1.

Workmen's Safety and Factory Hygiene Congress and Exhibition.—Thurs., Oct. 17, to Sat., Oct. 19, at Düsseldorf. Sponsored by the German Society for Workmen's Safety. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany.

***Newspaper and Rotary Letterpress Conference.**—Mon., Oct. 28, to Thurs., Oct. 31, at Harrogate. Organised by the Printing, Packaging and Allied Trades Research Association (PATRA), Patra House, Randalls-road, Leatherhead, Surrey. Tel. Leatherhead 4041.

***South Wales Institute of Engineers, Centenary Celebrations.**—Tues. and Wed., Oct. 29 and 30, in Cardiff and surrounding district. Apply to the secretary, the South Wales Institute of Engineers, Park-place, Cardiff. Tel. Cardiff 23296.

***British Sports Trade Fair.**—Mon., Nov. 11, to Fri., Nov. 15, at the Kingsley Hotel, Bloomsbury-way, London, W.C.1. Organised by the Federation of British Manufacturers of Sports and Games Ltd., Panton House, 25 Haymarket, London, S.W.1. Tel. WHItehall 5845.

Chemical Industries Exposition, 26th.—Mon., Dec. 2, to Fri., Dec. 6, at the New Coliseum, New York. Organised by the International Exposition Co., 480 Lexington-avenue, New York, 17, U.S.A.

***Solid State Physics, Second Conference.**—Thurs. and Fri., Dec. 19 and 20, at Imperial College, London, S.W.7. Theme: "Band Theory of Metals and Experimental Investigations into the Structure of the Fermi Surface." Apply to the secretary, the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Progress and Trends in Chemical and Petroleum Instrumentation, National Conference.**—Mon. and Tues., Feb. 3 and 4, 1958, at Wilmington, Delaware, U.S.A. Organised by the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

***Packaging and Confectionery Machinery Fair (INTERPACK).**—Sun., Mar. 2, to Sun., Mar. 9, 1958, at Düsseldorf, Germany. *Agents:* John E. Buck and Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

***Physical Society's Exhibition of Scientific Instruments and Apparatus.**—Mon., Mar. 24, to Thurs., Mar. 27, 1958, in the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Electron and Nuclear Resonance in Chemistry, Applications of; and Recent Work on the Inorganic Chemistry of Sulphur, Symposia.**—Mon., Mar. 31, to Wed., April 2, 1958, at Bristol. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

***Prestressed Concrete, International Congress.**—Mon., May 5, to Sat., May 10, 1958, in Berlin. Organised by the Fédération Internationale de la Précontrainte, Paris. Apply to Mr. P. Gooding, c/o the Cement and Concrete Association, Terminal House, 52 Grosvenor-gardens, London, S.W.1. Tel. BELgravia 6661.

***Production Exhibition.**—Mon., May 12, to Wed., May 21, at Olympia, London, W.14. Organised by the Institution of Production Engineers. Apply to exhibition offices: 32 Millbank, London, S.W.1. Tel. TATe Gallery 8134.

***Gauge and Tool Exhibition.**—Mon., May 12, to Wed., May 28, 1958, at Olympia, London, W.14. Organised by the Guage and Tool Makers' Association, Standbrook House, 2–5 Old Bond-street, London, W.1. Tel. HYDe Park 3451.

***High Tension Networks, International Conference on.**—Wed., June 4, to Sat., June 14, 1958, at Fondation Berthelot, 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Réseaux Electriques (C.I.G.R.E.) Apply to the secretary, British National Committee, Thorncroft Manor, Dorking-road, Leatherhead, Surrey. Tel. Leatherhead 3423.

***Automation Exposition and Congress, Fourth.**—Mon., June 9, to Fri., June 13, 1958, in New York. Organised by Richard Rimbach Associates, Management, 845 Ridge-avenue, Pittsburg 12, Pa., U.S.A.

***British Electrical Power Convention.**—Week commencing Mon., June 16, 1958, at Brighton. Theme: "Electricity and World Progress—Britain's Contribution." Organised by the British Electrical Power Convention, Eastcastle-street, London, W.1. Tel. MUSeum 4040.

***Steric Effects in Conjugated Systems, Symposium.**—Tues., July 15, to Thurs., July 17, 1958, at Hull. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

***Combustion, Seventh International Symposium on.**—Thurs., Aug. 28, to Wed., Sept. 3, 1958, at Oxford University, and the Royal Institution, Albemarle-street, London, W.1. Organised by the Combustion Institute, 936A Union Trust Building, Pittsburg 19, Pa., U.S.A. Communications to The Combustion Institute Committee, c/o The Institute of Fuel, 18 Devonshire-street, London, W.1. Tel.: LANgham 7124.

***Large Dams, International Commission on, World Power Conference.**—Mon., Sept. 15, to Sat., Sept. 20, 1958, in New York. Communications to the secretary, British National Committee on Large Dams, 201–202 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966.

***Gearing, International Conference.**—Week commencing Mon., Sept. 22, 1958, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

***Electronic Computer Symposium and Exhibition.**—Fri., Nov. 28, to Thurs., Dec. 4, 1958, at Olympia, London, W.14. Apply to Mr. J. F. Richardson, technical secretary, Radio Communication and Electronic Engineering Association, 11 Green-street, London, W.1. Tel. MAYfair 7874.

In Parliament

BUSINESS BEFORE THE HOUSE

Parliament resumed its sittings on June 25, after the Whitsun recess, and, in addition to subjects of mainly political concern, a wide range of economic and industrial matters is expected to receive the attention of the two Houses during the coming weeks.

The first sitting day in the House of Commons, the 18th allotted supply day of the present session, was mainly devoted to a debate on an Opposition motion relating to the Gowers Report on "Health, Safety and Welfare in Shops, Offices and Railway Employment" and to a discussion on shops' closing hours. Wednesday and Thursday were expected to be employed in making further progress with the committee stage of the Finance Bill. To-day, it was the intention of the House to give consideration to certain private members' Bills. Later on, it seems certain that considerable attention will be given to the law relating to mental health, including the industrial aspects of this problem, and a major debate on road questions is also likely in the near future.

In all, 17 Acts received the Royal Assent, just prior to the Whitsun recess. These included the Export Guarantees Act, the National Insurance Act, Blyth Harbour Act, the Marine Society Act, and the City of London (Various Powers) Act.

TEACHERS' TRAINING EXTENDED

In a brief statement shortly before the Whitsun adjournment, Sir Edward Boyle, Bt., the Parliamentary Secretary to the Ministry of Education, announced that the Government had decided to extend from two years to three the course of training which leads to the status of qualified teacher. The change would be made in 1960 and would apply to all students entering training colleges for general teachers in and after September in that year. The necessary changes in the regulations would be made later.

During the brief debate that ensued, Sir Edward said that the change would mean bringing the position in England and Wales into line with that in Scotland and Northern Ireland. The choice of 1960 for the introduction of the longer courses was in order to take account of the prospect of a sharp decrease in the number of children at school after 1961, and it would mean that there would not have to be any halting of the process of reducing the sizes of classes. The change would not be accompanied by any significant expansion of training colleges and the output of trained teachers would be reduced by about one-third, but the Minister of Education, Sir Edward affirmed, was satisfied that the resulting numbers were likely to be sufficient to meet the demand for teachers in the 1960's. He promised to consider a suggestion by Captain E. W. Short (Labour) that the new three-year course should be raised to the status of a university level and culminate in a degree in education.

UNIONS v. STAFF ASSOCIATIONS

Problems involved in the setting up of national negotiating machinery in the banking industry were raised by Mr. Alfred Robens (Labour). He claimed that the National Union of Bank Employees have more than 49,000 members, but were denied the right of collective bargaining by the greater proportion of British banks.

Mr. Iain Macleod, the Minister of Labour and National Service, told the House that these matters had been discussed between officers of his Department and the various parties interested on a number of occasions. Apart from the National Union, there were a number of staff associations representing employees in these banks, most of which were affiliated to the Central Council of Bank Staff Associations. When representatives of the National Union and the Central Council made a joint request in 1956, to the Ministry of Labour for assistance in securing a meeting with the Committee of London Clearing Banks to discuss proposals for national machinery, the Committee pointed out that two staff associations had decided against the policy of joint conciliation machinery. A third staff association was not a member of the Central Council. The directors of these banks declined to take part, therefore, in any discussions on joint conciliation machinery.

Recently, officers of the Ministry had had further talks with the National Union and the Central Council, and from these discussions it was clear that there had been no change in the situation generally. The talks also revealed a fundamental difference between the two bodies in their conception of the purpose of national machinery. The discussions had come to nothing largely because there was no agreement on the staff side, and, equally, there was no agreement on negotiating machinery between the employers and the various associations. In this country, there was no compulsion, and the Minister of Labour could not compel, any employer to recognise any particular body or association. Until the staff side came more closely together, Mr. Macleod said, he could not see any move from the present position.

EUROPEAN FREE TRADE AREA

In answer to a request from Captain H. B. Kerby (Conservative) for a statement, Mr. Nigel Birch, the Economic Secretary to the Treasury, said that the Council of the Organisation for European Economic Co-operation had considered the progress of the negotiations for the establishment of a Free Trade Area in Europe which had been going on in Paris for the past three months.

Good progress had been made in the negotiations, but the subject was obviously one of great complexity in itself, besides being closely connected with the arrangements for a common market provided for in the Treaty of Rome, which had not yet been ratified. Some time must necessarily elapse before definite proposals would be available for the consideration of the different Governments. It was not expected that the various questions involved would be sufficiently clarified to warrant holding a ministerial meeting of the Council of the O.E.E.C. in July, as had been previously envisaged, and the meeting would be held as early as practicable in the autumn. This modification of the timetable would enable the deliberations of the three working parties which had been set up to continue into July.

Mr. Birch said that Mr. Peter Thorneycroft, the Chancellor of the Exchequer, had been entrusted by the Council in February with the task of co-ordinating the negotiations, and he would continue with that work and with informal conversations with other ministers.

COMMONWEALTH ECONOMIC DEVELOPMENT

A request was put forward by Mr. Bernard Braine (Conservative) for a statement on the nature of the replies received from the Commonwealth Governments to the communication of the Secretary of State for Commonwealth Relations on the need for developing Commonwealth economic prospects. He was informed by Mr. C. J. M. Alport, replying on behalf of the Earl of Home, that the Government's undertaking to consult Commonwealth Governments regarding suggestions made in the House during the debate on Commonwealth economic development had been duly discharged. The proposals were that a Commonwealth Development Agency should be set up to carry out research into Commonwealth development and co-ordinate schemes where possible, and that a Commonwealth Bank should be formed, to which Commonwealth Governments would contribute, for investing in development schemes.

The views of the Commonwealth Governments had now been received. In general, all the Governments, while sympathetic of the motives which had inspired the suggestions, were doubtful of their value. A considerable contribution to the economic development of some Commonwealth countries had already been made by other Commonwealth countries, but, having regard to the fact that the United Kingdom was the only such country which was a net overseas investor, most of the Governments pointed out that a Commonwealth Development Agency and a Commonwealth Bank would not, in themselves, increase the availability of capital for investment. Some replies emphasised the practical difficulty likely to be encountered by such an Agency in the allocation of priorities, and the undesirability of duplicating existing institutions and facilities for investment, or for the collection and dissemination of information in this field.

The United Kingdom Government, Mr. Alport said, agreed with the conclusions embodied in these replies. At the same time, they would continue to seek, in consultation with Commonwealth Governments, other practical means of furthering common objectives in regard to Commonwealth economic development.

Allotting Government Contracts

Practices in the award of Government contracts were referred to by Mr. Frederick Willey (Labour). He asked the Minister of Labour and National Service if he would review the possibility of extending the practice of Government Departments of costing their contracts, so that they might be able to offer to sheltered workshops a large number of their contracts, in accordance with the suggestion of the Piercy Committee. Mr. Robert Carr, the Parliamentary Secretary to the Ministry of Labour, replied that this suggestion was at present being considered by the Departments concerned.

Industrial Wages Board

The Minister of Labour and National Service was pressed by Mr. Alfred Robens to set out his proposals for the setting up of an authoritative and impartial body to consider the wide implications in the present movements of wages, costs and prices. Mr. Iain Macleod said that he and Mr. Peter Thorneycroft, the Chancellor of the Exchequer, were having exploratory discussions on the subject with representatives of industry and of the various nationalised undertakings, and with the Trades Union Congress. The proposals were in a very tentative stage, however, and, in a matter as important as this, it was right that a statement should not be made, until all the parties concerned had been fully consulted.

Rural Electricity Supply Experiments

An inquiry was made by Mr. W. M. F. Vane (Conservative) regarding the results of experimental schemes into the use of the Lloyd-Mandeno single-wire earth return for rural electrification. On this subject, Mr. Reginald Maudling, the Paymaster-General, stated that five experimental schemes were now in operation, but the electricity Boards were not yet in a position to reach general conclusions about the possible usefulness of the system.

Electrical Industry Exhibits at Hanover Fair

Captain H. B. Kerby wanted the President of the Board of Trade to take steps to ensure that the British electrical industry, as the nation's major exporter, obtained the fullest facilities for exhibiting at future fairs at Hanover. He drew the attention of the President to the requirements of the fair authorities that bookings had to be lodged by the end of June and that all future exhibitors must contribute an interest-free loan of 170 marks per square metre of space booked. Mr. Derek Walker-Smith, Minister of State to the Board of Trade, in his reply, put forward the view that it was for the electrical industry in Britain to take the initiative in this matter.

Mr. Walker-Smith told Captain J. Baird (Labour), who inquired why the Goverment had refused licences for some East German goods hitherto admitted into this country independently of barter arrangements, that there had been no recent change of policy by the Government in this respect.

THE HUMAN ELEMENT

Where Do Graduates Come From?

The inquiry commissioned by the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom has now been published under the title, *Applications for Admission to Universities*. As would be expected from such auspices the report is a thorough and significant piece of work. Its points can only be touched upon here.

Much of the data does not refer to Oxford and Cambridge although enough is available to give a general overall picture. The report covers: number of applicants and their distribution, origins, educational background, social background, financial assistance, proposed careers, non-admitted applicants and unfilled places. The exercise thus takes its place in a growing literature on the background and ambitions of the undergraduate population.

One point from a wealth of information may be mentioned. Most people of working-class background chose teaching as a career, according to analysis of the questionnaires, but few whose parents were teachers followed them in that career. Is this what is wanted? Should such people be encouraged to go for security thus ensuring at least some supply of teachers or is it all wrong and should those of different social background be scught? Can both be attracted to teaching? This is going to be a vital issue before long if the number and quality of teachers does not improve, especially in technical subjects. Education for a technical career is fast becoming a major problem of public policy. The interest it already arouses among busy, prominent people can be seen from the report by the Institute of Physics just issued called *The Education of Physicists in Universities and Colleges of Technology* (price 6s.).

Quality Engineers

The editorial of the Engineering Society Journal of University College comments that the reputation of the engineering faculty of University College rests " with the quality of the graduate produced, not with the contents of its syllabus." The context was a plea for a broader education for engineering graduates, in which " quality engineers " were defined as " men who can see further than the ends of their own drawing boards." The introduction of a compulsory course on the presentation of technical information in the third-year syllabus of the electrical engineers course, for which the tuition includes tutorials as well as lectures, was warmly praised. The presentation of information course and courses in economics and law are described as important steps towards providing an education for the engineer. But why not also the civils and the mechanicals? The shortage of time and staff prevents the introduction of such subjects and of tutorials. Only a reduction in the number of topics taught in the third year could provide both. The journal argues that there is no reason why the syllabus should be considered inviolate.

Writing in the same issue of the journal, Professor H. M. Harlow of the Engineering faculty considers the problems of the graduate in the industry of tomorrow. There has been " a phenomenal growth in the breadth of scientific knowledge required as a background to professional status." There has also been a growth in specialisation. What is needed, argues Professor Harlow, is that teachers should ensure that " there is as much correlation and unification as possible in related studies." Also, that the engineering student should introduce a balance in his activities and contacts with students in other fields so that he will gain " a deeper understanding of the significance of his own work and theirs and will see more clearly how it all comes together in the great structure of human knowledge." Thus the problem is stated —how, in this age of considerable demands on the specialist, can an engineering student find time to become an educated man?

Twenty Years After

There were marked changes in the pattern of employment in the 20 years which elapsed between the Census of 1931 and that of 1951. Just how big they have been can be seen from the General Register Office's full report on industry taken from the 1951 Census. Over the period of 20 years there was something like a 20 per cent. increase in the labour force but this was accompanied by fairly drastic changes in the ability of different industries to absorb workers.

Biggest gains, measured in employment, were in various branches of engineering and in chemicals and iron and steel. Employment in some types of engineering (taking only the larger categories at that) doubled. In the case of aircraft, the rise was very much greater. There was a spectacular increase in chemicals, which is close to engineering in one sense.

Industries losing workers on a large scale were domestic service, coal mining, textile weaving and clothing. Allowance has to be made for the fact that the 1931 Census was taken at the depths of a depression and the later one in prosperous times. To that extent, the figures emphasise the growth of capital goods industries, among which engineering is outstanding. But even when allowance is made for that fact, the growing importance of engineering is outstanding.

Omnibus Collision

Six unions are now supporting strike action over the provincial bus drivers' dispute. Money, like misery, acquaints a man with strange bedfellows. Altogether this affair now concerns a wide cross-section of union opinion (the E.T.U. are supporting strike action and the A.E.U. are expected to be in sympathy before this issue is published).

The dispute concerns the final offer made by the employers, which the unions consider leaves too great a differential between the rates paid in the Provinces and in London. The London Transport Executive says that it grants higher rates because of the arduous work of bus-driving in London, but the strength and toughness of the T. and G.W.U. in the London area has a good deal to do with it. Most provincial bus drivers are also members of this union so the conflict is to a great extent a domestic problem for one union. There is a long-standing disagreement within the union on this question of differentials and union delegates have expressed themselves forcibly on the subject although the executive is not committed in the matter. It might be better for all concerned, including the public, if it were.

As it is, there is every prospect of a struggle at the public inconvenience on two fashionable problems of the moment in management-labour relations, namely, wage differentials and domestic difficulties within a union. By forcing the issue this way, the unions are hastening the time when the problems of the T. and G.W.U. will become more than of internal concern.

Children's Reading

Professor Harlow, quoted in another note on this page, wrote that one of the most important steps that a student has to take is " to learn how to learn." The schoolboy who comes up and is thrown straight into an engineering course may never adapt himself to the requirements of true learning, the exercise of the mind in acquiring understanding and the training of the senses to develop awareness and discernment. Many learned people have for the past few years argued hotly on the pros and cons of specialisation at university. Fewer have troubled about specialisation at schools, and even fewer about the promotion of awareness and the development of understanding in the young child. Yet it is in the years of school up to the certificate of education that a child can, if well guided, acquire the broad basis necessary to absorb, without damage, the immense amount of specialised knowledge required in most scientific or technological jobs.

A report published by The Ministry of Education (*Standards of Reading*, 1948 *to* 1956—H.M.S.O.) indicates that there has been a steady improvement in the standards of children's reading. Pupils aged eleven are now on an average nine months more advanced than pupils of the same age in 1948. Eight per cent. of the children aged eleven read better than the average pupil aged fifteen: " inquiries into these good readers showed the wide range of reading and varied tastes, and the extent to which opportunity for these things is now given by many primary schools. They also show the importance of home encouragement." Such progress is encouraging indeed, if maintained it could simplify considerably the lack of teachers at universities who seek to produce " educated " graduates.

END OF THE 183RD VOLUME